CHAPTER 1

INTRODUCTION

1 Background

1.1 Introduction to Marsh Mugger

Only two species of Crocodiles like *Gavialis gangeticus* and *Crocodylus palustris* were reported to abundant in Nepal (Whitakar, 1987) out of 21 species, 7 sub species and 3 families of Crocodile that survive in earth (Zug, 1993). The Mugger Crocodile (*Crocodylus palustris) is* literally called "Crocodile of the Marsh". It is also called the Indian Mugger or Iranian Marsh Mugger or Persian Crocodile as *Gandu*. In Pakistan's coastal regions of the Makran and delta marshlands of Sindh, it is also known as the "Indus Crocodile". It is found throughout the Indian subcontinent and the surrounding countries. Its exact locality data ranges from Nepal, India, Srilanka and Burma to Iran (K Shah, 1995). In two species of family Crocodyladae, all modern Crocodiles belong to Mugger (*Crocodylus palustris),* under sub family Crocodylinae is listed vulnerable list on the appendix II of CITES (IUCN Nepal, 1995a) and catagory status V in IUCN redlist (IUCN Nepal, 1995b). The Mugger is usually called Marsh Mugger in Nepal. The name "Mugger" is a corruption of the Hindi/Urdu word. 'Magar' means "Water monster" in the Hindi/Urdu language. This is in turn derived from "Makara", the Sanskrit word for Crocodile (Britton, 2002).

The Marsh Mugger is mostly an endemic species in the Indian continent. Historical range of it extends from Iran. The 1992's IUCN action plan for conservation of Crocodiles classifies Mugger as high priority species for action and rates the population of which is severely depleted/endangered (Thorbjarnarson *et al.*1992). Muggers are widely distributed in the Nepal (Shah and Tiwari, 2004). In Nepal, It is reported from BNP, CNP and all development region of the Nepal and not found in more than 400 m (K. Shah, 1995). In SWR, it also found with Gharial association in areas like Bahuni Nala, Chaudhara River and Shinali Nala (Andrew and MC Eachern, 1994).Their distribution range mostly in Terai lowland of Nepal including East and West Rapti, Narayani and Koshi River system (Shrestha, 2001; Koshi Wetland Newsletter, 2008). Largest number of the Mugger Crocodiles in Nepal found in Rapti River within CNP. As reported by Thorbjarnarson *et al.* (1992), Muggers are not believed to inhibit Karnali River and may be found in its tributaries. But, high numbers of the Mugger Crocodiles were reported by Shrestha (2001) in Karnali River

and its tributaries. In Karnali, Babai and Narayani, they coexisted with Gharial. Currently Mugger Crocodile is reduced to isolated population primarily with protected habitats such as in SWR, BNP and CNP contain viable population. The Mahakali, Bahuni River adjacent to SWR (Shrestha, 2001; Andrews and Mc Eachern, 1994) and Rani Tal inside it represent excellent habitat of this Crocodile (BPP, 1995b) but are reported to be reduced in number nowdays in these areas (Andrews and Mc Eachern 1994). Mugger Crocodile is decreasing in number due to poaching activity in Nepal. Poaching is the major threat found to Crocodile particularly at Kaligandaki and Narayani river tributaries. BPP (1995b) and Bhandari, (1998) reported large number of Mugger Crocodile in Beeshazari Lake. Lami Tal in Chitwan (Bogati, 2003) and Ghodaghodi Lake Complex in Kailali district also provide important habitats for the globally-threatened Marsh Crocodile (CSUWN, 2009).

1.2 Crocodile Mythology in Nepal

Crocodiles are closely associated with deities in Indian and Nepalese mythology (Singh, 1986). They were regarded and worshipped as Vahana (vehicle) of goddess Ganges (Maskey, 1989). Crocodile also talked under Nepal as "Gohiko Ansu" (Crocodile's tear: means faking sympathy only betraying sympathizer). Crocodiles are cruel animal and ugly. Tears dropping are only thought to pretend other. So if anybody shows sympathy only verbally not heartily in action such a condition is called as Crocodile's tear (Rai, 2003).

1.3 Marsh Mugger and its habitat

Mugger Crocodile lives in the freshwater rivers, Lakes and marshy places. It also can adopt to live in the reservoirs, irrigation canals and other manmade water bodies. It prefers slow moving in the shallow area like in the Lakes, reservoirs and even in saltwater lagoons. It could not sustain in the high current water bodies (Whitakar, 1987; Whitkar and Whitakar, 1989). All Crocodiles are semiaquatic, hunting and feeding in water but basking for a few hours each day (Zug, 1993). Generally, the Muggers use basking long time in the day time in winter season. Mugger tends to bask in midstream on rocks or muddy banks (Groombridge, 1982). It remains at the bottom of water during sunny days and night. Sometime the Mugger immerses the half of body into water. They have been reported to migrate considerable distance overland in search of more suitable habitat. Mugger Crocodile segregated by its habitat where found together with Gharial. It does not range widely moving a

maximum distance only of 10.7 Km in an 18 months period (Bustard and Singh, 1982). Mugger Crocodile and other crocodilians communicate with each other using stereotyped acoustic and visual signal that convey reproductive, territorial, and other information (Senter, 2008). Most of Crocodile breeds by egg (Webb *et al.,* 1984) Mugger Crocodile breeds by laying eggs. The peak time of egg lying of *Crocodylus palustris* in India and Nepal is during the wet season like February to August. (Whitakar and Whitkar, 1984; Ferguson, 1985). The average size of the *C. palustris* eggs from south India was 74 mm x 47 mm x 128 mm (Whitakar and Whitkar, 1984). The average size of eggs at Narayani river were 78.9 ± 5.3 mmsd x 49.6 ± 2 mmsd x 114.2 ± 11.3 mmsd (Maskey, 1989).

1.4 Population status of Mugger Crocodile

Srilanka have largest remaining wild population of 2000 (Whitaker and Whitker, 1979). The 3000 of population was estimated in India (Whitaker and Whitker, 1989). Bangladesh reported to have 118 Mugger Crocodiles only (Gholi and Shagari, 1993). A survey in Nepal initiated in 1993 reported occurrence of Marsh Mugger in different area like Mahakali, Koshi, Babai Rivers of Nepal etc (MC Eachern, 1994). Shrestha (2001) mentioned 120-150 numbers of Mugger Crocodile in his book 'Herpetology of Nepal'.

1.5 Crocodile and Wetlands

Wetlands support several species of endemic or globally threatened flora and fauna. Given that all living creatures require water, it could be argued that all organism are wetland dependent, however most of organisms depend significantly on wetland habitats for food and breeding. Of the 20 endemic vertebrate animals found in Nepal, 17 including 8 fish, 9 herpetofauna species are wetland dependent and among them Marsh Mugger is one (IUCN Nepal, 2004). The 2003 IUCN red list includes nine reptilian species including critically endangered Bengal roof turtle (*Kachuga kachuga),* Elongated tortoise (*Indotestudo elongate*) and Gharial (*Gavialis gangeticus*), vulnerable broad Snouted Crocodile (*Crocodylus palustris*), crowned river turtle (*Hardela thurji*), Indian eyed turtle (*Morenia petersi*), Black pond turtle (*Geoclemys lamiltonni*) and Keeled land tortoise (*Melanochelys tricarinata*) under list. Beside this, wetlands are with both economical and ecological function (IUCN Nepal, 2004).

Nepal's wetlands have great ecological diversity (Scott and Polle, 1989). The flood plains, Oxbow Lakes and other depressions which retain water after the flood water has receded support a rich diversity of wildlife (Shah, 1997) but Nepal's wetlands are facing tremendous anthropogenic pressure. Human induced activities such as deforestation, destruction for resource collection eg fishing, gravel and drifting collections and the water drainage for the irrigation are the activities with largest impact for the deterioration of the wetland habitats (Bhandari, 1998). So conservation of wetland is necessary. Mugger Crocodile is the keystone species of the slow flowing freshwater ecosystem hence it is quite important in biodiversity conservation (Mulkozi, 2000). Crocodiles help to the distribution of the nutrients from the bottom of water body to the surface of water. So, they increase the primary production and fish population and maintain the aquatic ecosystem (Mulokozi, 2000).

Crocodiles are important for several aspects such as their existence indicate the healthy aquatic ecosystem and their hide and meat has good commercial value. Crocodilians are living members of Archosauria an ancient group of reptiles which included Dinosoraus and progenitors of birds. Now a days wetland biodiversity is under threat from encroachment of wetland habitat, unsustainable harvesting of the wetland resources, industrial pollution, agricultural runoff, siltation and introduction of the exotic and invasive species in wetland ecosystem. Encroachment of the wetland is primarily due to the drainage for irrigation, reclamation and fishing, filling in for solid waste disposal, road construction, commercial, residential and institutional development, conversion of sites for aquaculture, construction of dam barrages and other barrier for controlling water flow and digging ditches in site where there is no inflow of water, discharges of sediment by nearby area, grazing and removal of soil from the site. The construction of dam and constructions in large River are reducing the number of Crocodiles in wetlands of Nepal (Shrestha, 2001) by reduction of wetland areas, deposition of silt and sediments and eutrophication and deterioration of water quality (GoN/MFSC, 2002b). Beside, the importance for Crocodiles, wetlands act like sponges; they provide flood protection by reducing flood peaks and reducing shoreline erosion to the downstream water users. They are the kidneys of the landscape because they filter sediment, nutrients, and contaminants from inflowing water there thereby, improving water quality. To local and migratory animals, they are supermarkets that provide a wide variety of foods (Groom *et al*. 2006).

1.6 Conservation status, importance and threats of Mugger Crocodile in Nepal

Principle threats to Crocodiles in Nepal are incidental catch in fish nets, egg collections, egg predation by animals, habitat destruction and hunting use of the Crocodile parts for medicinal purpose (Groombridge, 1982). The 1992's IUCN action plan for conservation of the Crocodiles classified Mugger as a high priority species for action and rates the population status in Nepal severely depleted/endangered (Thorbjarnarson *et al*. 1992). Hunting of the Crocodiles is prohibitory in Nepal but this protection appears to only applying to the Gharials but not enough for Muggers and which is not legal protection to out side of the National Park and Wildlife Reserves of Nepal (Andrew and MC Eachern, 1994). Therefore unless the existing population is supplemented by additional number and proper protection is not followed, these Crocodiles will soon disappear in the wild.

The Crocodiles have bundles of importance. The penis, skin and eggs of Crocodiles have great medicinal and economic value. The *Crocodylus palustris* is under the vulnerable list of the CITES. Its population is low in Nepal. If the population is not maintained in a time it may extinct from the Nepal. So the conservation is necessary. No more care is being given to the Mugger conservation in Nepal other than Kasara conservation project Chitwan for Gharials where Muggers are also associated with Gharials and automatically preserved. Therefore survey for additional habitats, selection of restocking sites for Muggers and conservation programmes should be extended. Mugger is an ideal animal for ranching and farming.It has classic hide value in world market. In Nepal ranching could contribute to feral Mugger conservation and habitat preservation by generating revenue from local communities on whose goodwill Crocodile depend on survival. Beside this experimental ranching and well managed farming programme, Nepal could generate immediate revenue for Crocodile management and justify the survival of this species. This would afford enduring benefits to not only Mugger but also Nepal's entire wetland ecosystem including avifauna and herpatofauna (Andrews and MC Eachern,1994).

1.7 Legal conservation of Crocodile in Nepal

Legal protection opf Crocodile began in 1973, under the National Parks and Wildlife Conservation Act. Hunting of Crocodiles is no longer permitted (National Parks and Wildlife Conservation Act, 1973). The Gharial is listed under the protected animal category of the National Parks and Wildlife Conservation Act, 1973. Any person who

kills or injures this animal shall be punished with a fine ranging from forty to seventy five thousand rupees, or face an imprisonment ranging from one year to ten years or both. GoN Nepal launched a captive breeding program for the rehabilitation of Gharial in 1978 with the support of Frankfurt Zoological Society. The rearing project, originally for Gharial only, was set up at Kasara in CNP. The facilities in Kasara now hold both Gharial and Mugger where the Mugger is unintentionally protected. In 1982, facilities were added at BNP for Gharials and Muggers. IUCN Nepal initiated a program for Mugger conservation in 1992 which derived from the accelerated decline of wetland habitat and lack of detailed information on the status of Crocodiles. The recently created Wetlands Inventory and Conservation Programme augment the Crocodile project by supplying logistic support and facilities. The Crocodile Project received funds from USAID and IUCN for the initiation of a conservation program and a feasibility study for sustainable utilization of Crocodiles in Nepal.

To involve the individuals and organizations for farming, breeding and research of valuable NTFPs and wildlife as well as to support biodiversity conservation and generate income from such endeavors, GoN decided to adopt the Working Policy on Wildlife Farming, Breeding and Research, 2003, on August 28, 2003. This policy permits for private commercial farming of Gharial with the objective of supporting Gharial conservation. But the Mugger is not considered as such. The interested individual, organizations and institutions shall obtain permission from the Ministry of Forests and Soil Conservation (MOFSC). The applicant should pay NRs. 40,000 to get permit and DNPWC may provide seed animal by charging NRs.40, 000 ((National Parks and Wildlife Conservation Act, 1973).

1.2 Wetlands

The Nepali term for wetland is 'Simsar'. The informal group in Nepal at the first informal meeting on wetlands management in Nepal attempted to define wetlands as "It is a landmass saturated with water due to high water table through ground water, atmospheric precipitation or inundation and it may be natural or artificial, permanent or temporary, static or flowing and fresh water or brackish" (Shrestha and Bhanadari, 1992). Ramsar convention 1971 had broad definition covers the majority of all categories of the wetlands including most of the productive land are considered among the most productive ecosystem in the world (Halls, 1997). The wetlands for international importance are called as Ramsar sites. Ramsar Convention was signed in

1971 in Ramsar (Iran) defines wetland as "The areas of Marsh, Fen, Peatland or water whether natural or artificial, permanent or temporary with water that is static or flowing fresh, brackish or salty including areas of marine water, the depth of which low tide does not exceed 6 meters and may include riparian and coastal zones adjacent to wetlands or island or water bodies of marine water deeper than 6 meter at low tides lying within wetlands (Ramsar Convention Bereau, 2002). The term wetland doesn't have universally accepted definition because of the plurality among uses, regional variation, biological diversities and richness in cultural values. Thus meaning varies from person to person (Bhandari, 2009).

1.2.1 Wetlands in Nepal and their Classification

The Terai occupies a narrow belt along Nepal's southern edge on the Indian border Indian covering about 16 % of the total area of the Nepal. Altitude range varies from the 67 m - 300 m above the mean sea level. A classification of the wetland found in this region was made with number in the parenthesis referring it the wetland types as defined by IUCN (Scot, 1989).

Table 1: IUCN's classification of the Wetland: number and system.

Wetland type system	**Wetland type subsystem**	**Wetland type number**
Lacustrine system	Oxbow Lake with swamp forests (swamp forests are seasonally inundated areas with associated tree species adapted to these condition)	13
	Freshwater Lakes and associate marshes	14
Palustrine system	Permanent fresh water marshes	15
	Seasonal fresh water marshes	16
Riverine syste	Perennial Rivers and steam	11
	Seasonal and regular rivers and streams	12
	Flood plain and marshes	18
Man made system	Agricultural pond	14

(Source: BPP, 1995b)

Wetlands have been classified into three categories from the view point of management plan.

1. Wetlands lying in protected areas or buffer zones

2. Government and public wetlands outside protected areas

3. Wetlands in private area

(Source: GoN /MFSC, 2002a)

There are 242 wetland sites in Nepal out of which 163 sites lies in the Terai region and rest of the 79 in the hills and mountain region. According to the developmental region, 64 wetland sites lies in Mid Western region, 52 in the Central region, 42 in the Eastern region and 32 in the Mid Western region (IUCN Nepal, 1996). Among the wetlands of Nepal, 10 lie in the Ramsar sites of international importance. IUCN on its inventory of Terai wetland found siltation and sedimentation problems in 112 Lakes out of 163 Lakes surveyed on its wetland inventory (Bhandari, 1998). Wetland species are critically threatening by anthropogenic activities such as deforestation, unregulated hunting, dam construction and increased pollution level from discharge of untreated effluents and agricultural practices (Joshi *et al.* 2001).

The total wetland resources consist of permanent fast flowing rivers to seasonal streams, high altitude glacier Lakes to lowland oxbow Lakes, gholes to swamps and marshy lands, riverine flood plains to paddy fields and man made reservoirs to village ponds, comprising approximately 5 % (816954 ha) of total land areas of Nepal. Out of total wetlands in Nepal, rivers cover 395000 ha (48.35 %). Irrigated paddy field covers 398000 ha (48.71 %) marginal land/swamps/Gholes cover 11500 ha (1.4 %). Reservoirs cover 15000 ha (0.18 %) Lakes cover 5000 ha (0.61 %) and village pond covers 5954 ha (0.72 %), (DoFD, 2002). Kanchanpur district also contained of the large number of the wetland sites. Among them, most of the important are Rani Tal, Betkot Tal and Kalikitch Tal etc. Most other important wetlands also lie inside SWR. Some of the important are like Dodhari Tal, Lalpani Tal, Kalikitch Tal, Rani Tal, Laare Tal, Padau Tal, Tara Tal, Hathia Tal, Purano Tal, Gauthali Tal, Sikari Tal, Solgudi Tal, Bahuni Nala, Shahili Nala, Chaudhara River, Mahakali River etc (IUCN Nepal,1996), Naya Tal, Tinkuna Tal, Thulo Pani Tal, Bijuda Tal, Lalpani Sabgada Tal etc (Thapa, 2007).

1.2.2 Water quality and Lake Sediment

The objectives of water quality issues are to define the background condition, status and long term trends and changes identities, describe and explain the major factors that effect water condition, status, changes and trends (FAO, 1999). Amount of plant

nutrients present in the water also predict the future trends of plant growth together with climatic suitability. The environmental condition within the bodies of water and in the watershed and air shed all influence the eutrophication factors within the Lake that modulate the impact of nutrient enrichment include food web structure, exchanges between sediments and water, shape of basin and movement of water within Lake, climate and hydrological condition of the watershed further after impact of the eutrophication (UNEP-IETC, 1999). Lakes are more complex and fragile ecosystem than rivers. They do not have self purification capacity and therefore they readily accumulate pollution. Because of their ecological and economic significance and their relevant vulnerability to degradation, Lakes require more concerned attention than is applied generally to rivers and stream basins. Sustainable use of stream and reservoirs is being threatened around the globe (World Bank, 1995). The eutrophication in Lakes and reservoirs is enriched with plant nutrients mainly contained of Phosphorous and Nitrogen, which enter the solutes and bound to organic and inorganic particles. Floristic and faunal diversity of wetland is also influenced by several physicochemical parameters such as water transparency, velocity, depth, Hydrogen ion concentration, nutrients etc (CBIP, 1979; Burlakoti, 2003).

The ionic composition of fresh water is dominated by dilute solution of alkali and alkaline earth metal compounds particularly bicarbonate, carbonate, sulfate and chlorides. The concentration of four major cations Ca^{+2}, Mg^{+2}, Na^{+}, K^{+} and four major anions like HCO_3^{-1}, CO_3^{-3}, SO_4^{-2} and Cl^{-} usually constitute total ionic salinity of water for all practical purposes (Wetzel, 1983). The three major mechanics controlling the salinity of world surface water are rock dominance, atmospheric precipitation and evapo-traspiration processes (Gibbs, 1970; Feth, 1971; Kilham, 1975; Stallard and Edmond, 1981; Wetzel, 1983). Nitrate is common form of inorganic entering freshwaters from drainage basin in surface waters, ground water and precipitation and orthophosphate is only directly utilizable form of soluble inorganic phosphorous (Wetzel, 1983). The process by which either Nitrogen or phosphorous washed downstream, locked in to sediment or denitrified, ensure productivity of many Lakes will largely reflect the contemporary nutrient supply and will increase or decrease to changes in this (Moss, 1998).

The sediments in Lake offers reflection of what is happening in water column and the Lake as such, they can be regarded as tape recorder of historical development, often

called geological archive (Hankinson and Janson, 1983: Hankinson, 2004). The sediments also affect the condition in water through re-suspension processes because the animals living in the sediments play the fundamental role in the Lake bottom ecosystem. By extracting sediment cores and conducting a number of analyses, information can be obtained on changes that have taken place in ecosystem (Thomas *et al*. 1972). The sediments in freshwater ecosystems are essential environmental compartments due to its capacity to store or release different compounds from or to water column. The gradual accumulation of organic compounds in water and sediments can lead to progressive state of eutrophication resulting in improvement of water quality changes in composition and structure of biota and increase in potential toxicity related to substance with adverse biological effects. For certain trophic levels, a secondary level of eutrophication origination from nutrient released from bottom sediments, also might occurs (Martinova, 1993).

1.2.3 Wetland succession, native and alien invasive species

Enhanced growth and increased abundance of aquatic plants often result in reductions in water quality (Wetzel, 1983). Nowdays the vegetation succession by native and invasive species in the Lake became common and spreading through the wetlands of Nepal. An alien species has been defined as the species that is non native, indigenous, exotic foreign and/or introduced the ecosystem other than its natural home. Any species including its seeds, eggs, spores or other living entities through which it is capable of multiplying and propagating in a foreign ecosystem could be an alien species. The global invasive species programme has defined IAS as follows. “IASs are organisms that have been moved from their native habitat to a new location where they cause significant harm to environment, economic system and/or human health (http://www.gisp.org) or in simple terms, the alien aggressive species which displace native species by competition by predation, parasitism and competition for space and nutrients. They are termed as invasive alien species. It is important however to know that alien species are not only invasive species some of native species also shows invasive characters may be called invasive native species (Bhatt, 2006).Wetland INS species might have degradive effect in wetland by nutrient addition. Sometimes the term noxious weed may be used for invasive species it is legal designation used specifically to plant species that have been determined to be major pests of agricultural ecosystems and are subjected by certain restriction”. (http;//www.nps.gov/plants/alien/bkgd.htm). IAS comprises both positive and

negative impacts. IAS is considered as second biggest threat after deforestation to biodiversity conservation. They disrupt the ecology of the natural ecosystem by displacing the native plant and animal species as well as degrading the landscapes and diverse biological resources. They alter hydrological flows and the condition as well as change characteristics of the soil structure, sand chemistry etc (Randall and Marinelli, 1996). IASs are also considered as the biological polluters (Westbrooks, 1991). A study conducted by the US fish and wildlife services estimated that 42 % of the plants and animals on US endangered and threatened species list are at the risk primarily because of IAS which are termed as the greater threat for the native species decline after habitat loss (Schmitz and Simberloff, 1997).

Many native organisms are dependent on native plants for the food and shelter. This type of the animal-plants association has evolved over thousand of years. It is estimated that at least 123 species of the organisms rely on each plant species in the temperate region while up to 30 organism depend on the single plant species in the tropical regions (Gould, 2004). The introduction of the IAS breaks such relationships. Invasive alien species sieve as host reservoirs for the plant pathogen and other organisms that can infect and damage desirable native and ornamental plants. Some of the invasive species are free floating macrophytes which occur submerged or on the surface also exhibit great diversity in morphology and habitat like *Lemna, Pistia, Eichornia, Chara* etc develop so profusely. The high development of these plants can result in the excessive loading of the OM and nearly total attenuation of light below the surface. As a result, period of several reductions and depletion of dissolved oxygen can result loss of invertebrates and fishes (Wetzel, 2001). Beside this some free floating species contain high evapotranspiration ratio. The *Pistia straiotes* is one reported to be highest evapotranspiration rate of 19.9 mmd^{-1}. Similarily *Echornia crassipes* contain rate of 6-11 mmd^{-1}(Brenzy and Sharma, 1973).

Nepal has not made any comprehensive study and research to asses the status and impacts of IAS. As a result the country does not have management strategy to prevent further introduction and spread of IAS. The IUCN's guideline for preventing biodiversity loss due to IAS (2000) has been designed to increase the awareness and understanding of the impact of IAS. It provides the guidelines for the prevention of the introduction and, reintroduction and control as well as irradiation of the IAS (IUCN, 2000). In Nepal, there is no much awareness about IAS. Despite various

arrangements nobody is responsible for research and management to regulate introduction of IAS. There is specific regulation guidelines, manual, laboratory, taxonomic capacity for identification of IAS. IUCN Nepal is only one which make inventory on IAS to fulfill the Knowledge gap (Tiwari *et al*. 2005).

1.3. Introduction to study area

1.3.1. Kanchanpur district

It is situated at the distance of the 488 Km from the Kathmandu. It covers area of the 1610 km^2. One fifth of the district is covered by the SWR. Topography of the area is flat plain with elevation of the 176 m from msl which lies between 80 ^{0} 3' and 80 ^{0} 31'E longitude and 28 ^{0} 33' and 29 ^{0} 80' N latitude. Dadeldhura and Kailali districts lies at north and east of the Kanchanpur and river Mahakali flows through the western and southern edge of Kanchanpur. The climate is subtropical in nature. Monsoon brings heavy rainfall. The temperature ranges from 4^0 C to 42^0 C (DNPWC/PCP, 2004). Kanchanpur district contain many Lakes amog them Titara Tal, Paderini Tal, Banda Tal, Sano Banda Tal, Naini Tal, Baria Tal, Bantaria Tal, Piyari Tal, Bichki Tal, Aanp Tal, Gusta Tal, Shova Tal, Lalpani Tal, Shikari Tal, Kalikitch Tal, Tara Tal, Peli Tal, Nunkhani Tal, Barkhaune Tal and Rani Tal are most. Among all Lakes present here, Banda Tal have highest area of 45 ha and Rani Tal lies in seventh position having 11 ha area (Bhandari, 2009). SWR lies in the extreme in the far western region of Nepal, southwest of the Terai in Kanchanpur district. It is one of Nepal's smaller protected areas covering 305 km^2 Suklaphanta lies in 28º 53' N to 80º 11' E and ranges in altitude from 150 m to 600 mm (WWF Nepal, 2000). The forest rest consists of forests of Sal, Sissoo and Khair and savannah, supported by better-drained soils on higher terrain in the northeast (Schaaf, 1978). The reserve possesses the largest grassland phantas in Nepal. These are of both national and international importance for birds and other wildlife (Baral and Inskipp, 2009). Sal is the dominant forest type in the reserve with Khair (*Acacia catechu*) and Sisso (*Dalbergia sissoo*) alongside rivers. Some 54.7% of the reserve is covered by broadleaved forests of Sal (*Shorea robusta*) with forests of Sissoo (*Dalbergia sissoo*) and Khair (*Acacia catechu*) along rivers, and grassland and marsh in the southwest where soils are of recent alluvium. There are seven small Lakes, Rani Tal, Salghaudi Tal, Kalikitch Tal, Bhatpuri, Kumari, Shikari and Tara Tal, with associated marshes where dense grasses of *Phragmites karka* and *Saccharum spontaneum* predominate (Baral and Inskipp, 2009).

The international border between Nepal and India demarcates the southern and western boundaries of the reserve. The Luggabugga Florican Reserve in India lies adjacent to the southern boundary of Suklaphanta. The Syali and Radha rivers form the eastern and western boundary respectively for the part of the reserve that extends north of the east-west highway. The reserve was a famous hunting area for many years and was declared as a Royal Hunting Reserve in 1969 with an area of about 155 Km^2. The reserve was gazetted as the SWR in 1976. Later the reserve was extended eastwards by an area of about 150 Km^2 to create more habitat and a corridor from the Terai into the Churia hills for the seasonal migration of wildlife. Suklaphanta is important both nationally and internationally for its extensive grasslands or phantas that constitute almost half the reserve's vegetation and a much greater area than grasslands in the rest of lowland Nepal. The main grassland, Suklaphanta proper, is the largest protected patch of continuous grassland in Nepal. It is approximately 16 Km^2 in area. The main grass species include *Imperata cylindrica* and *Heteropogon contortus.* In the eastern half of the main phanta the grassland is damp with large areas of marshes and pools. There are other smaller phantas in the reserve which are important for birds. These are Singhpur Phanta, Karaiya Phanta, Dudhiya Phanta and some smaller phantas. SWR reported to have presence of large reptiles include the Indian Rock Python (*Python molurus)* and Marsh Mugger (*Crocodylus palustris).* The total of 27 fish species has been recorded in rivers, Lakes and ponds of the reserve (Bhatt and Shrestha, 1977).

1.3.1.1 Location of Rani Tal

Rani Tal is located in eastern side of SWRs 24 km from the Mahendranagar (headquarters) and 18 km from the Majgaun, the headquarter of SWR (Majapuria and Majapuria, 1948) with 28^0 50.2' latitude and 80^0 13.2' longitude at altitude of 140 m msl (Bhandari, 2009). In east ward site of the Rani Tal it lie Hariyaphata, Suryaphata, the dense cover of forest at west and north and outflow closed with low height closed dam in southward site. This wetland is with shoreline of 100% open forest and contains both inlet and outlet as outlet is now checked by small dam (Field survey, 2009). Eastern site of the Lake is full of Dhap or swampy ground covered by reeds and tall grasses like *Phragmites karka* (Field survey, 2009). Baral also has reported Rani Tal is chocked to be of native vegetation like *Phragmites karka* highly (Baral and Inskipp, 2009).

The area around Rani Tal is best example of swamp (Shah and Shah, 1999). It is also ornithologically important (BPP, 1995b). Bhandari (2009) reported that it has area of 11 hactor categorized in IUCN wetland type 8 and 10 with overall high ranking and is important for plant harvesting and recreation. But filling was great threat to the Lake. The Lake has high scenic value. This Lake is mostly used as recreational purposes. The Lake's 3/4th area were covered by vegetation. The eastern portion of the Lake is covered with reeds and water ferns. Public have direct access to this wetland. The wetland is protected by the government. Government of Nepal in Biodiversity assessment of Terai wetlands (1995) reported that Rani Tal as excellent wetland (BPP, 1995b).

Location map of study area

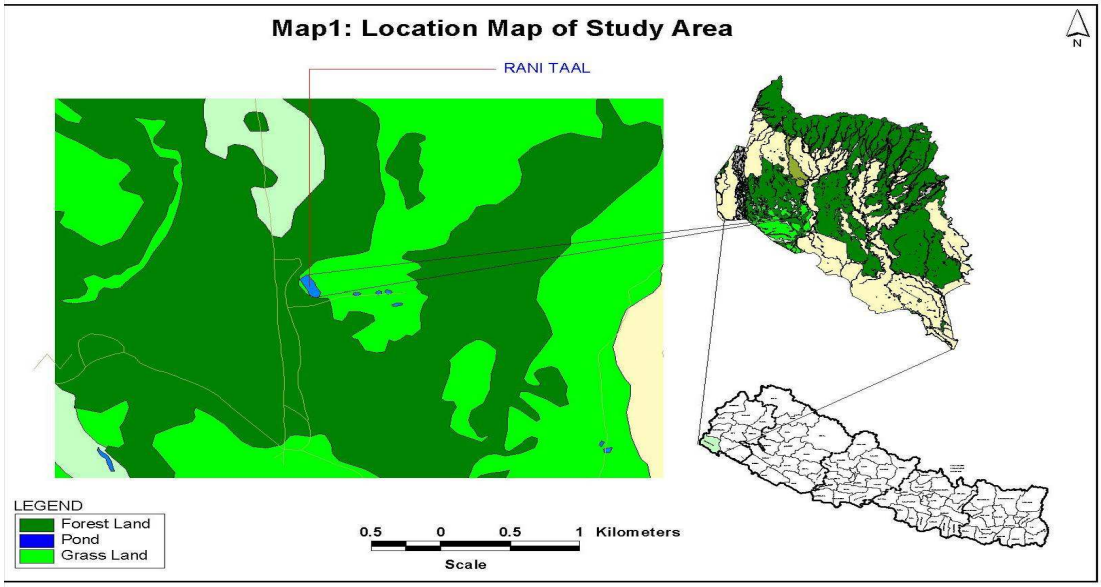

Fig. 1 Location map of study area

1.3.1.2 Historical background of Rani Tal

Rani Tal is a natural Lake nestled in Sal forest. This wetland was estimated to be formed about 350 years ago due to shifting of Chaudhara River, hence an oxbow Lake (DNPWC/PCP, 2004**).** According to local resident Mr Bhole Man Thakur, who was previous dweller of Singhpurphanta (which formally was location of Tharu village and now flourishing by grassland), as one of the queen of Tharu's king Singapal Baba used to visit at the Lake for swimming snd bathing at past time; hence name was given as Rani Tal. Some people also believed that the Lake was artificially built by

Singhpal Baba for easier for her queen to swim and bath in past time (Personal communication: Thakur Bholeman, 2009). Nearby Rani Tal There is a temple of Singhpal Baba in Singhpur considered as incarnation of Lord Shiva. This small shrine at first appears to be only a piles of rocks, but after a few minutes inspection reveals that the rocks are carved and very very old (Field survey, 2009). This gives you a reminder of just how old the civilizations in this part of world really are. Local people go there for worship during festivals. Rani Tal has high aesthetic and recreational value and provides impressive varieties of wildlife. On occasion of Shivratri some people worship the Singpalbaba. During the Dhashain festival, people also come here to worship Singphal Baba. Hindus still perorm animal sacrifices here (DNPWC/PCP, 2004**).**

In early 1990s Rani Tal's water got drop down. This trend was identified as threat to wildlife and water fowl that use the Rani Tal. In 1997 a low dam built near southern edge of Rani Tal at site of southern Machan with private donation (Lohani, 2000) which was later destructed by flooding due to the heavy rainfall and again built by SWR, DNPWC. Seasonal lowering of water level in the Lake usually occurs. Sometime it tends to drying or retains very low water. Boring was performed many times to refill the decreased level by reserve office but it could not success due to heavy extrusion of silt and mud. So, now the Wildlife Reserves and Irrigation office, Kanchanpur are trying to construct canal from Chaudhara River to recharge the Lake (Personal communication: Upadhaya Gopal Prashad, 2008). In past days the encroaching vegetations had been cleared time to time but this has been neglected in recent year due to lack of economy. Some work was carried out at Rani Tal in 1998 and was supported by the reserve authority and assisted by help from the Silent Safari Camp and Bird Conservation Nepal. This included making an earthen embankment over 600 m long and 3 m high to trap a larger quantity of monsoon rain and so significantly raise the water level of the Lake (Baral and Inskipp, 2009). Appropriate and regular management was not performed and clearing of the vegetation was not made now days hence Lake was highly encroached by the vegetation (Personal communication: Bam Karna Bahadur, 2009).

1.3.1.3 Biological attributes of Rani Tal

Marshy land of the Rani Tal is highly productive all year round but best in autumn (September to October) and winter (January to February). In mixed woodland along

Lake margin, many wintering Ducks seen along the Rani Tal (www.widlife.nepal.com, 1981). The Lake is wintering area for sizable number of several species of waterfowls and provides staging area for many species during their migration (BPP, 1995b).

Rani Tal is situated in area of seasonally flooded tall grassland and undisturbed Sal (Shorea *robusta*) with thick lianas with abundant undergrowth. Eastern site of the Lake is full of the *Syzygium cumini* forest with short length of Hariyaphata (Field Survey, 2009). Lake is covered with patches of islands or reed beds which are being feeding habitat for birds and reptiles like crocodiles. The reed beds are covered with species of *Phragmites karka, (In* reeds-approx 70%) and various tall grass species (*Themeda arundinacea, Imperata* species, *Arundo donax, Erianthus ravennae, sachharum* species, *Oryza rupipogan* etc). There is covering of *Pistia stratiotes* and *Trapa quadrispinosa* in water surface with *Ludwingia adscendens*. Submerged community is equally rich processing *Potamogatoen pectinatus, Hydrilla verticilliata and Najas minor.* Lake Vegetation was found to be medium to rich while as surrounding vegetation is dominated with a number of grass species and tree species. Lake is situated in area of seasonally flooded tall grassland and undisturbed Sal (*Shorea robusta)* Forest with thick linnas and abundant undergrowth. The species present areat margins are *Phragmites karka a*nd various tall grass species (*Themeda arundinacea, Imperata* species, *Arundo donax, Erianthus ravennae, Euliopsis binnate, Heteropogan contortum, Phragmites karka, Sacchrum spontanium, Oryza rupipogan etc*). Wetland and surrounding forest have a rich mammalian wetland fauna e.g. Predators as *Panthera tigris, Lutra lutra* is reported to occur. Occasionally, the wetland and surrounding forest had big mammalian faunas such as *Panthera tigris, Lutra lutra* are reported to occur. The Lake is wintering area for sizable number of several species of waterfowl and provides a staging area for sizable number of several species of waterfowl and provides a staging area for many species during their migration. Resident species include *Ardeola grayii, Egrata alba, E. intermedia, Sarki airnus, P. nigar, Euphippiorhynchus asiatticus, Anas strepora, A. platyrhynchos, A. acuta, A. querquedula and A. clypeata.* The Lake is also rich in herpetofauna and fishes. It is found to be supporting large population of *Crocodylus palustris*. Fishes like Charangi *(Chauna gachina),* Garahi *(Chauna punctatus*), Sidre *(Puntius species),* Singhi *(Heteropneustes fossilis),* Mungri *(Claris batrachus),* Dedawa *(Esomus dandricus),* Dira *(Rasbora daniconius),* Bam *(Mastacembelus species)* found in Rani

Tal (BPP, 1995b). It is most fascinating Lake for water birds and different migatory birds (Majapuria and Majapuria, 1998; Karpowicz, 1985; Fleming, 1977) also important Lake of Shukalphata for many wetland bird species. The Lake is rich in many bird species. High diversity of bird species were reported with total number of 1073 birds. Bird species observed during the survey are 40 *Anas strepora* (Gadwall), 200 *Anas acuta (Northern* pintail), 15 crested serpent eagles (*Spilornis cheela*), 156 purple Gallinule (*Porphyro porpyhyro*), 15 bank mynah (*Acridotherus ginginianus)*, 101 Yellow Wagtail and others according to BPP, 1995b.

1.3.1.4. Climate

The area has a tropical monsoon climate with four different seasons: Winter, Spring, Summer and Monsoon. The hot sticky days give away to the monsoon rain that last until September. Hot westerly winds of up to 160 Km per 4 hour have been recorded in summer season (DNPWC, 2004). The months of December and January are fairly cold and misty with occasional frost. The average temperature during winter ranges from 10-20 ^{o}C and rises to 22-25 ^{o}C (DHM, 2009). Over 90% of the annual precipitation falls during monsoon between June and September. The relative humidity remains fairly high throughout the year except in the dry months of the pre-monsoon period. From the analysis of precipitation and temperature data of Mahendranagar from 1997 to 2007, highest precipitation of 1046.9 was reported in month of August in 2000 and lowest of 1 mm precipitation was observed in month of January, 2006. Similarly highest maximum temperature of 39.9 was reported in month of June, 2005 and minimum temperature of 5.2 was reported in month of January (Annex: 20, Fig. 1 and 2).

a) Average annual range of maximum and minimum temperature trends

The average annual minimum temperature found somewhat lower in 1998 and 2003. The highest annual maximum temperature was reported in 2003 (Fig. 2)

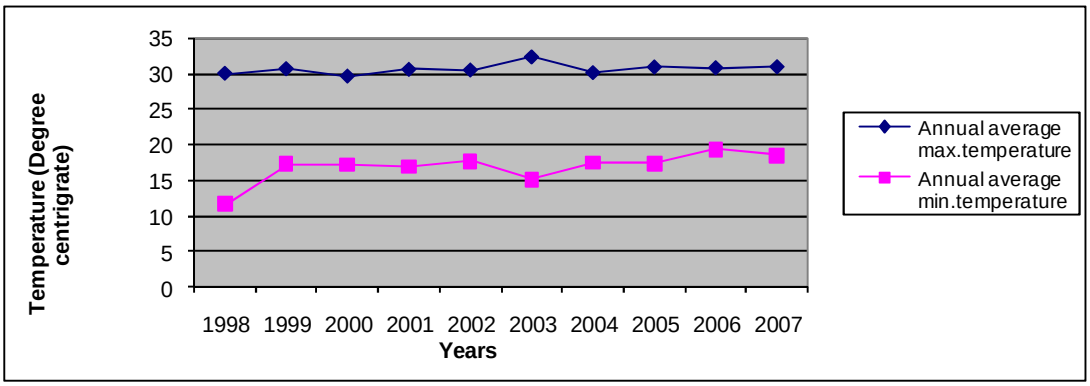

Figure 2: Average annual range of maximum and minimum temperature

b) Average annual range of annual Rainfall pattern

Highest annual rainfall was reported in 2000 and lowest was reported in 2003 (Fig. 3).

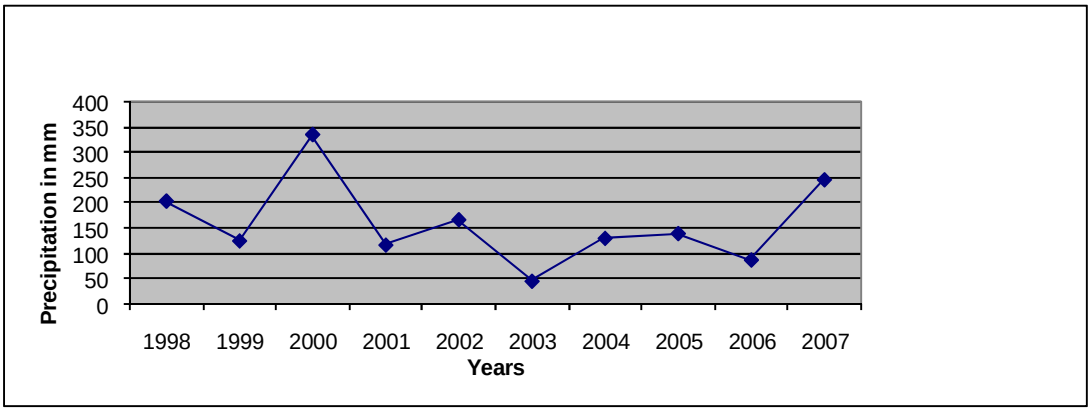

Figure 3: Average annual range of precipitation

1.3.1.5 Geology

Pradhan *et al.* (1967) reported the geology of the area as very similar to the gangetic alluvium. It is underlain by crystalline rock of allocthonus material basement and lowerappe roots. Toward north it meets Siwaliks (territory) of Indian geology and then the Mahabharat ranges. The Siwaliks of Churiya hills are composed of coarsely bedded sand stones and rocks, clay and conglomerates. Fringing the outer margin of it is Bhabar zone, composed of boulders, gravel and loose sand on somewhat steep slope. They disappear themselves while crossing them to heavy percolation through the gravel. They subsequently reappear in the Teari zone just below the Bhabar Zone. This keeps Terai to be abounding with dense forest vegetation. The soil of Terai is derived from old as well as new alluvium brought by rivers from hill and mountain in North. The old alluvium is formed further away from the river tract which no longer subjected to flooding while new alluvium is seen in relevant flood plains. The soil so far observed is loamy sand, sandy loam, loam silty loam and clay loam. Differences in topography rainfall, temperature, leaching etc have created the local diversity among soil derived from the same parent materials. The soil analysis of the bottom found the high OM and soil of surrounding is somewhat low OM. Surrounding soil is highly acidic in nature (Pokharel and Song Hu Chun, 2008). The texture of soil varies from clay, sandy clay to loamy soil (Field Survey, 2009).

1.3.1.6 Hydrology (Feeding channel)

Rani Tal is rain fed Lake (Lohani, 2000) and it is also faded by the surface inflow, atmospheric input and intermittently through Hagnia khola (Nala) which flow from north to south of SWR (Field Survey, 2009). The retained water though rainfall and flooding from surrounding could not outflow due to closed embankment built at southern site of the Rani Tal. Water level from North east to the south west is close to forest but remaining part to the grassland having heavy coverage of the *Phragmites karka* and other species. Water quality shows the alkaline (Bhandari, 1996) and neutral nature (Pokharel and Song hu Chun, 2008) in Rani Tal.

1.4 Literature Review

1.4.1 Wetland Studies in Nepal

According to the published literatures in the field of freshwater environment of Nepal, The starting of the wetland studies in Nepal seemed to be from 19th century onward. Kirkpatrick (1811) can be considered as the pioneer scholar, who studied some fishes (*Tor sp. Schizothorax sp., Barilus sp. and Anguilla sp.*) of Rapti Khola, Tadi Khola and Trishuli River in 1793 during his political visit to Kathmandu. In the 19th century, only two researchers, Hamilton (1819 and 1822) and Atkinson (1882) studied the fishes of Nepal. Hamilton (1819) described the occurrence of two groups of fishes (Mugils and Carps) in the hill regions of Nepal. This is considered as the first scientific report of fish from Nepal. Don D (1825) made study on flora of Nepal including wetland flora. Atkinson (1882) investigated fishes of Trans-Himalayan region e.g. Kumaon, Garhwal, Nepal and Tibet Further Hamilton (1883) listed fish fauna of Nepal "An account of the fish found in river Ganges and its branches.". Most of studies of 19th century are focused on fish faunas.

During the early and middle of the 20th century, only a few scholars (e.g. Boulenger, 1907; Regan, 1907; Hora, 1937 / 39 and Menon, 1949) studied the fishes of Nepal. Regan (1907) reported the occurrence of seven fishes collected from Kathmandu, Sundarijal and Pharping. Among the identified fish species, he classified five fishes as Nepalese species and *Diptycus annandalei* (Nov). Boulenger (1907) described about Batrachia, Reptilia and Fish of Nepal and Western Himalayas. The study on aquatic macrophytes was seemed to be started from 19th century. Burkill (1910) seemed to be pioneer in field study of aquatic macrophytes. Limnological history of Nepal is very old. Hora (1937 / 39) was one of the pioneers of Icthyologist who described about

158 fish species from rivers and pools of Halchowk, Mugling, Nagarkot and Sundarijal of Nepal. Menon (1949) investigated the distribution of 52 fish species in the Koshi river of Nepal and presented geographical distribution of 126 Himalayan fishes. The study on freshwater environment of Nepal in the different fields (physicochemical parameters of water, plankton, macro invertebrates and fishes) was carried out by various researchers only after 1950. Brehm (1953) is seemed to be first limnologist in 19th century, who inspired aquatic fauna of Kalipokhari in eastern Nepal. He studied the occurrence of three genera of zooplankton (*Diaptomus, pseudodiaptomus and Cladocera*) in Kalipokhari pond of eastern Nepal. Taft (1955) collected fishes from different parts of Nepal and submitted a report listing 94 fish species. His study indicated about the potentiality of aquaculture development in the Terai region of Nepal. Hirano (1955 and 1969) made an extensive study on freshwater algae of Nepal in Gorkha, Tanahu and Synjga districts of Nepal and identified 271 freshwater algal species. Dewitt (1960) made a checklist of 102 fish species of Nepal belonging to 21 families. For the first time Menon and Datta (1961) collected Psilorhynchoides pseudochenies from Tamakoshi River and described it as a new endemic species of Nepal (Mennon, 1962). Menon (1962) collected fishes from Koshi, Bagmati, Gandaki and Karnali rivers and described the occurrence of 126 fish species in these rivers. Forster (1965) and Poelt (1965) studied Desmides and Myxophyceae of Khumbhu Himal. Muller (1966) also studied the algae of Khumbhu Himal and observed the occurrence of *Spirogyra nepalensis* in that region. Uyeno (1966) collected zooplankton from north-east Nepal.

Water analysis in lentic ecosystem in Nepal was pioneered by work of Loffler who conducted limnochemistry of plankton from high altitude Lakes of Mount Everest in 1964 (Loffler, 1969). Loffler, (1969) made study in Mountain Lakes of Nepal of Khumbu high mountain, Everest of Nepal. He made study on Pachhpokhari, Shey phoksundo, Gosaikund and Mt Gaur, Sankar devoid of aquatic macrophytes. Wetland Fauna also have been described by Hirano (1969). Loffler (1969) is considered as the pioneer scholar in the field of limnological studies of lentic environment in Nepal. He studied the morphmetry, physicochemical parameters of water and plankton of 24 high altitude (4500 – 5600 m above sea level) Lakes and ponds. Kusel-Fetzmann (1969) described the distribution of algae flora in Mt. Everest and Gauri Shankar Himal. Rajbanshi (1971) observed the sexual dimorphism of Snow trouts (Asala). Likely Banarescu (1972) contributed to the knowledge of Cyprinoidei from Nepal.

Majumdar, Majupuria and Shrestha (1972) reported new records of fish species from Nepal. Shrestha (1973) described a new species of Cobitidae from Nepal; *Lepidocephalichthus sp.* Further, Hickel (1973b) made an extensive study on the physicochemical parameters of water and phytoplankton of four Lakes of Pokhara. He identified altogether 76 species of phytoplankton in the Lakes of Pokhara valley and observed the dominancy of *Melosira islandica*. He also described the distribution of phytoplankton in two ponds of Kathmandu valley (Hickel, 1973a). Bhatta and Shrestha (1973) also reported the occurrence of 27 species of fish in Mahakali River. Most of Studies are focused inside Kathmandu Valley's Watersheds and Lakes. Hickel (1973b) made study on aquatic plants of Nepal. Hickel made study on Phewa, Begnas, Rupa and Khaste in the Pokhara valley found oligotrophic nature of lake. Daems and Dumont (1974) studied the distribution of rotifers and recorded *Scaridium* sp. as a new species for Nepal. Dumont and Velda (1977) studied the occurrence of zooplankton (Cladocera and Copepoda) in Nepal. Joshi (1977) described some Myxophyceae of Kathmandu Valley. Shrestha and Majupuria (1977) carried out study on the fishes of Janakpur. Shrestha (1977) reported two new records of fish from Nepal. Further she described the fish fauna of Nepal and fishes from Rara Lake in 1978 and published a book entitled fishes, fishing, implements and methods of Nepal in 1994. In 1999 she reported about cold water fish and fisheries of higher altitudes (Asala). Malla *et al.* (1978) carried out the study on the aquatic insects (16 species) of various water bodies of the Kathmandu valley.

Similsrily, Ferro and Swar (1978), Ferro (1978/79) studied limnology in many Lakes of Nepal. Ferro (1979) made study on Rara Lake, Similarly Dinerstein (1979) reported many wetlands flora in Rapti River bank and CBIP (1979) reported floristic and faunal diversity of wetland influenced by physiochemical parameters in Nepal. Ferro (1978/ 79a and b) made the limnological investigation of lentic environment of Pokhara valley in order to make a plan for the management of fish culture (understand implications for fisheries and fish culture). In 1978, he also reported the freshwater medusae from Rupa Lake. Shrestha (1978b) investigated the fishes of Rara Lake. Shrestha (1978a) observed some aspects of ecology and behavior of *Anguilla bengalensis* (Gray) in the temple pond of Chabdibarahi and the adjoining rivers of Western Nepal. Swar recorded a single species of *Cladocera* from Rara Lake. New Era (1978/79) made project study on Chisapani, Karnali focusing socioeconomic impact of wetland. Swar and Fernando (1979) sampled *Cladocera* from both Lakes

and rivers of the Pokhara valley. They identified altogether 23 cladoceran species of which 11 species were recorded as new species for Nepal. They made further study on cladocerans of Pokhara valley in 1979. Ferro (1979) also carried out the limnological investigation of Rara Lake. Shrestha (1979) described the distribution of fish species in Bagmati River. His report indicates the occurrence of 54 species of fishes in the Bagmati River. Upadhaya (1979) recorded two new species of phytoplankton, *Oscillatoria princes* and *Oscillatoria proboscides* in Narayani River. Ferro and Badgami (1980) described the biology of commercially important fish species of both lentic and lotic environment. Swar and Fernando (1980) studied on the occurrence and ecology of crustacean zooplanktons in Begnas Lake. Yadav (1980) showed general composition and distribution of zoobenthos in Rajdal pond of Lagankhel. Yadav (1981a) conducted population studies of freshwater snails of a Lake and three ponds of Kathmandu Valley. Swar and Fernado (1981) studied the seasonal variations on zooplanktons in Phewa Lake. Shrestha (1981) recorded 26 species of fishes in the upper zone of Bagmati river (from Sundarijal to Chovar) as biological indicator of pollution. He also described 108 fish species of Koshi river 34 species of Trishuli River, 102 species of Narayani River, 74 species of Karnali River and 69 species of Mahakali River. Yadav (1981b) also studied physical environment and bottom fauna of a historical pond Ranipokhari in Kathmandu.

Rajbhandari (1982) carried out study on the physiochemical analysis and benthic fauna of the Taudaha Lake. Upadhaya and NN (1982) studies on River pollution in Kathmandu Valley. Yadav (1983) studied benthic macro-fauna of four ponds of Godavari fish farm, Kathmandu valley. Hamilton (1983) studied on Phewa Lake found oligotrophic; Nakanashi categorized Lake Phewa as mesotrophic.Yadav *et al.* (1983) study on aquatic plants of Nepal. Shrestha and Manandhar (1983) described the occurrence of 48 species of algae in various water bodies of the Kathmandu valley. Similarly, Terashima (1984) made study on 47 rivers of Nepal. Shrestha (1984) reported chemical pollution in Bagmati and Bishnumati River. Nakanishi *et al.* (1984) studied physicochemical parameters of three Lakes Phewa, Begnas and Rupa of the Pokhara valley. Shrestha (1984) recorded 8 fish species in Sunsari District of Nepal. For the first time, Terashima (1984) studied on the fishes of Rara Lake and recorded three new species of fishes. Aizaki (1985) described the trophic status and water quality status of high altitude Lakes in Mt. Annapurna region. Edds (1985, 1986 and 1987) studied the fishes of water bodies within the CNP, Kali Gandaki River and

Narayani river of Nepal. He reported the occurrence of 113 native fish species in the water bodies on the National park. Similarly, he described the distribution of 111 fishes in Kali Gandaki and Narayani rivers. He also recorded 8 fish species new to Nepal. Mahato and Yadav (1985) described the distribution of 65 fish species in Dharan, eastern Nepal. Jha and Shrestha (1986) identified 57 fish species collected from Karnali River. They also observed their distribution in the river. Khatri (1986) reported Bishnumati is highly polluted than Bagmati River. Okino and Satoh (1986) classified Lake Rara as oligotrophic. Nakanashi (1986) made study on Phewa, Begnas and Rupa lake of Nepal. Yadav (1986) study on effect of pH on some Osmoregulatory organs of the fish *Channa punctatus* (Bloch) in Nepal. Aizaki *et al.* (1987) made study on high altitude Lake of Nepal. Gopal (1987) studied the impact of water hyacinth in wetland diversity. Environment Impact Study Project (EISP, 1987) study focused on the effluents discharged by leather and tanning in Birganj, Bhairhawa, Kathmandu. NAST (1987) examined paper mill effluents on the local biotic systems of Narayani and Orahi rivers as well as water quality of rivers located in central terai region of Nepal. Karki (1988) studied some of limnological aspects of selected water ecosystem of Udaipur. DSIVI (1988) made pollution monitoring of Bagmati River found highly polluted. Pradhananga *et al*. (1988) made water quality study on Pashupati area found Napit (1988) reported pollution problem of Pasupati area. Lohman *et al.* (1988) analyzed pre and post monsoon seasonal variation in limnology of Pokhara and Kathmnadu Valley. Mahato (1988) studied some physicochemical parameters of a temple tank (Kirtipur) in relation to zooplankton production. Bajracharya *et al.* (1988) documented water quality status of Passhupati area. Jones *et al.* (1989) carried most extensive limnological survey of 50 Lakes and ponds of midhills including Kathmandu and Pokhara valley found fair productivity. CEDA (1989) also concerned with study of industrial effluents of jute and iron industries in Biratnagar. Karmacharya (1990) made study on Bagmati river pollution and its tributaries found increased pollution level from Pashupatinath to Sundarighat.

Most of the dissertations are based on monitoring of water quality data. The study by Vaidhya (1990) and Tennyson *et al.* (1990) are also focused study on Bishnumati River. DISVI (1990) had made study on Bagmati River. Shrestha (1990) made study on Biological and physicochemical investigation of the Bagmati River with special reference to water pollution. Upadhyaya (1991) study on some physicochemical parameters affecting the zooplanktonic abundance of sewage stabilization, Dhobighat.

Halcrow and Fox *et. al* (1991) found that river water quality is good until they enter into urban area. Bhandari (1992) reported current status in wetland in Nepal. Crocodile management study in wetlands of Nepal also mentioned in Manamdhar (1991) and Maskey and Mishra (1981), Maskey (1989 and 1992). UNDP (1992) had made study on Bagmati River found highly polluted. NPC/IUCN (1992) found values higher than adopted by Nepal Bureau of Standard and Meteorology (1987). Rai (1988) made study on effects on water quality and Zooplankton communities on Growth of hybrid carp (Bighead carp, *Aristichthus nobilis* x silver carp, *Hypophthalmichthesis molitrix*) in cages NPC/IUCN (1992) reviewed water pollution at Tukucha and Dhobidhara or Bagmati River found water not capable of sustaining of aquatic life. Baral (1992) recorded 34 plant species comprising 6 aquatic macrophytes and 28 terrestial plants in Ghodaghodi Lake, Kailali. Baral also made study on wetland dependent birds in Chitwan. Yadav (1992) studied water quality and benthic fauna of the feeding river, Palung and streams Chalkher, Thado and Chitlang of the Kulekhani reservoir. Rai and Mulmi (1992) made observation of planktivorous fish species in floating cages of Indrasarobar reservoir. Shah and Giri (1992) studied the fish and fishing in Arun Basin eastern Nepal. Chetri (1992) reported the zooplankton of Bhimpokhari pond, Kritipur.

World Bank / Nepal (1993) reviewed the fish occurrence in upper zone of Bagmati river and described the 14 fish species with decreasing tendency of vulnerable fish species. Ghos (1993) reported study on physicochemical parameter and benthic community of Bagmati River. Rundle *et al*. (1993) made investigation of 58 streams in Himalayan Region of Annapurna, Langtang and Everest found 47 taxa of invertebrates. Mc Eachern (1993) made limnological survey of Devi Tal in Chitwan district. Rai (1994) studied distribution of zoo benthos in Manohara River observed greater varieties of benthic fauna in upstream. Joshi (1994) reported high value of BOD than threshold limit in Bagmati. He also had submitted water quality on Bishnumati river report same fact. Stanley *et al.* (1994) had made study on Bagmati River found highly polluted. Khadka *et al*. (1994), Raut (1994) found Bagmati river tributaries slightly polluted. Shah (1994) reported primary productivity and phytoplankton in relation to some physiological parameters of Kirtipur village pond. In same year, Thapa (1994) made ecological survey of village pond of Kirtipur reference to water quality and zooplankton. WMI and IUCN (1994) found productivity of oxbow Lake to Koshi Tappu was eutrophic category. Mahato (1994)

studied abundance and percentage distribution of zooplankton in sewage disposal pond of Dhobighat, Lalitpur.

Karki (1995) study on Manohara Rivers macroinvertibrates found less inveribrates in the polluted sites. Shrestha (1995) reported no fish in Gosikunda Lake but high plankton. Shrestha (1995) studied on Taudaha studied on physicochemical parameter. Yadav (1995) studied physicochemical parameter and benthos of Bagmati River. Shrestha (199) made study on physicochemical parameter and primary productivity of Taudaha Lake. Pradhan (1995) has investigated on Taudaha pond, Lavapukhu pond, Bhimpukhu pond found suitable for drinking. BPP (1995b) reported wetland biodiversity of 51 wetland sites in Terai. Baral (1995) reported the algae of Nepal Subha (1995) and Subha and Ghos (1996) recorded fishes from the Koshi river.

Shah (1996) reported Taudaha Lake with high productivity. Tamrakar (1996) conducted study on parameter distribution and abundance of zoo benthos in Manohara River with related to physicochemical parameter. Udas (1996) studied on ecological characteristics of Tamor Lake in CNP on Physicochemical parameter. MC Eachern (1996) also made study on Devi Tal, Rani Tal, areas. ENPHO (1996) found quality of water very poor at Sundarighat indicating higher BOD and Cl ion and value very poor water quality in Bagmati River. The hydrology division of Nepal GoN in 1996 also made study on main wetlands of Kathmandu valley found Bagmati, Bishnumati, Dhobikhola, Manohara and Hanumante rivers as high value of almost all parameters. ENPHO (1996) made study on eleven streams in head water region of Bagmati and Bishnumati River found high macroinvertebrate diversity and high coli forms. Bhandari (1996) reported the low Nitrogen content in Terai region of Nepal. IUCN (1996) reported 163 wetland sites belonging to lacustrine, riverine and palustrine habitat. Yadav (1996) studied the effect of physicochemical parameters on the distribution and abundance of zooplankton in Taudah (natural) Lake found that the population density and abundance of zooplankton fluctuated according to season. Yadav (1996) studied on water quality and biotic community of oxbow Lakes of the CNP. Aryal and Lacoul (1996) reported 19 species of diatoms from Punyamati River.

Bhattarai (1997) made study on wetland plants found 94 species of wetlands plants in Bardia. Similarly in Bhandari (1997) reported the status of wetland in Lumbini. Acharya (1997) reported productive nature of Ghodaghodi Lake and Narkodi Lake.

Shah (1997) reported fishing is cause of decrease in wetland dependent birds. Jayan (1997) made study on Bishazari Lake. Raya (1997) found degraded water quality in Bishnumati River by urban sewage and industrial water. Bhatt (1997) made study on physicochemical parameter in Taudaha lake. Bhagat (1998) recorded 68 fish species from Morang district, eastern Nepal. Rundle *et al.* (1998) described the micro-invertebrate communities in the stream in the eastern Himalayan Nepal. Jack and Silva (1998) carried out study on Nepalese water beetles. Manca *et al*. (1998) studied the aquatic organisms of high mountains Lakes of Khumbu valley. Baral (1998) reported high BOD value, low DO and High COD and high coliform Bagmati river. Pradhan (1998) showed very poor water quality in Bagmati River and its tributaries. Shrestha (1998) found 65 species of aquatic macrophytes from 7 Lakes of Pokhara valley. Rajkarnikar (1998) studied abiotic and biotic component of "Tagmaru Pukhu" in Lalitpur district. Jayram (1999) reported 106 fish species of Nepal. Shrestha (1999) conducted comparative study on the effect of some physicochemical parameters on the production and seasonal distribution of zooplanktons in the pond no.1 and pond no. 2 of central Fish Hatchery, Balaju, and Kathmandu. It showed that zooplanktonic abundance increased in the summer season than in winter season. Only few genera found regularly while most genera observed were irregular. There have been notable works in different aspect of limnology from 1970s to 1990s (Shrestha, 1999). Shah (199) made study on the variation of Zooplalnkton productivity of a village pond, Kirtipur, Kathmandu.

In 21 th century many studies were being performed like Sharma (2000) studied water quality of Bagmati River. Kathmandu from Panchghat to Chovar found almost all parameter above WHO limit. Grimmet *et al.* (2000) reported overgrown exotic plants in water body of Nepal Declining bird population. Shakya (2000) reported that the most urban water extremely polluted and unfit drinking purpose. Joshi *et al.* (2001) made inventory on 41 wetland sites in Kathmandu valley and collected 36 plant species belonging to 20 families. Similarly, Shrestha in 1990 reported different study in behavior of Crocodile in Karnali River (Shrtestha, 2001). Shrestha (1983, 1993, and 2001) also reported study on Crocodiles in different wetlands of Nepal. Shrestha (2001) reviewed the fishes of Nepal and reported a total of 182 fish species of Nepal. Adhikari (2002) recorded 59 and 52 species of aquatic macrophyutes in Khaste and respectively. Pariyar (2002) found major sources of Bagmati and Bishnumati River are domestic raw sewage, industrial effluents, solid and liquid wastes of different

nature. Vaidya (2002) described macro-invertebrates as a measure of water quality in upper Bishnumati stream, Kathmandu.Poudel (2002) made quality study of Bagmati river found maximum pollution. Prashad (2003) made study on Taudaha lake with effect of Limnology. Ingrid and Cox (2003) studied the distribution of diatoms as an indicator of environmental conditions in 235 streams of mountains and hills of Nepal. Ranjit (2003) described the distribution of microflora and fauna in the mountainous rivers of Nepal. Pokharel *et al.* (2003) concluded DO of water was very less of 2.94 mg/lt at Pashupati area and at Tinkune area. Acharya (2003) found eutrophic nature of Taudaha Lake. Rajbhandari (2005) made study on General Experiment on Physicochemical parameter of water Kathmandu, Nepal. Shrestha (2005) had submitted water quality on Bishnumati River. Koirala (2007) in Sirsira River Birgunj found magnitude of parameters not complying with WHO standards. Thapa (2007) reported water quality, waterfowl diversity and impact on wetland dependent birds in Jagadishpur reservoiur.

1.4.2 Study in Rani Tal

Bhatt and Shrestha (1973) reported the high coverage of the *Pistia straoites* in Rani Tal area**.**

Scot (1989) in "Directory of Asian Wetlands" reported that Mahakali River, Chaudhara River, Rani Tal and Sikari Tal as key wetlands of SWR. These wetlands were reported to be contained of endangered Gharials, Swamp deer, Marsh Mugger and Smooth coated Indian otter as key species. Scot also reported the high dominance of invasive species *Pistia straoites* in Rani Tal.

Suwal and Shrestha (1992) reported that Rani Tal's area decreasing day by day due to vegetation succession and reported vegetation succession as main threat in Rani Tal. They reported about 150 ha has turned in to the grassland due to vegetation succession. They reported Rani Tal as very much important for the wildlife and waterfowl conservation.

BPP (1995a, 1995b) conducted the survey in technical assistant of government of Netherlands reported different types of the littoral, infra-littoral vegetation, Marsh and adjoining terrestrial vegetation together with fish and bird species in Rani Tal. It is eutrophic Lake had found to be 8.1 pH with D.O of 8.8 ppm. The lake is up to 4 meter

deep. The Lake was reported to be rich in herpetofauna and fishes and supporting of large population of *Crocodylus palustris.* Three species of turtles were reported from this area. BPP (1995a, 1995b) in its inventory on Terai Wetlands reported 27 wetlands in Kanchanpur district among them siltation and sedimentation processes were found to continuing on in the Rani Tal. They also reported that 70% of the Lake area is covered with *Phragmites karka* with dominated *Sachharum spontaneum* around the bank. The remaining water body mostly covered by *Nymphia, Hydrilla, Valleseria* and *Pistia straoietes.* Beside this many species of water plants like *Arundo donax, Combopogon martini, Eulaliopsis trinata, Imperata cylindrica, Sachharum mungia, S. spontanium, Themeda species, and Vetiveria lawsoni* found to be colonizing the Lake area. They reported Lake as wintering area for waterfowl and different migatory species like *Ardea purpurea, Ardeola graysi, Egretta alba. E intermedia, Nicticorax nicticorax, Sarkidiornis melanotos, Parrage ungrants and* winter visitors include *Anas clypeata, A. platyrhynchos, A. acuta, A. quaquidala, A. strepera, Ephippiorhynchus asiaticus, Motacilla cinera, Phalacrocorax cabro and P. niger.* This wetland is very important for wildlife such as *Axis axis, A. porcinus, Cervus durauceli, Lutrogale perspicillata, Panthera tigris.* The Lake was found to supporting the viable population of *Crocodylus palustris* and protected reptile species *Python molurus.* BPP (1995b) on its survey also reported that no conservation measures had been taken in Rani Tal the Lake is diminishing day by day. But park officials considering of probability of re-diverting Chaudhara River bank in to the Lake.

Baral (1995b) reported a pair of Black-necked Stork (*Ephippiorhynchus asiaticus)* in Rani Tal in January and single birds were noted till March 1998 (Baral, 1997; 1998) and since then there are no known records of this bird from Suklaphanta. Baral and Inskipp (2009) reported that Rani Tal is the largest and potentially the most interesting of the Lakes. According to Baral and Inskipp (2009), a female type young Jerdon's Bushchat was trapped near Rani Tal in 2002, indicating the species had bred nearby which is now thought to be a rare and local breeding resident in Nepal. Jerdon's Bushchat is rare elsewhere in the Indian subcontinent and threatened by habitat loss. Blue-breasted Quail (*Coturnix chinensis),* Yellow-legged Buttonquail (*Turnix tanki)* and Grass Owl (*Tyto capensis)* are three other grassland specialities that have been recorded very rarely at Suklaphanta and are nationally threatened. As well as, the globally threatened and near-threatened birds given above several nationally threatened species occur on this wetland. Black Bittern (*Dupetor*

flavicollis), Yellow Bittern (*Ixobrychus sinensis)* and Striated Grassbird (*Megalurus palustris)* are residents recorded frequently at Rani Tal (Baral and Inskipp, 2004). In early May 1982 six wildfowl species including Comb Duck and Cotton Pygmy-goose (*Nettapus coromandelianus),* as well as 12 wader species including Greater Painted-snipe (*Rostratula benghalensis)* and the rare passage migrant Long-toed Stint (*Calidris subminuta)* were seen here. By comparison, habitats for ducks and waders were much reduced in April 2001 (Inskipp and Inskipp, 2001). He also reported that in April 2001 less than 10 % of the water at Rani Tal remained open in contrast to 1982 when a considerable water area was free of surface vegetation (Baral and Inskipp, 2009).

Bhandari (1996) reported that Rani Tal as important for thatching grass and recreation. Bhandari (2009) reported same area for the Rani Tal on "Preliminary inventory of Nepal's wetlands".The major threats found are siltation, and sedimentation. In his rank of threats with option high, poor, fair, average and excellent, This Lake categorized to high rank of threaten. He also reported that Kalikitch Tal, Lalpani Tal of the SWR is *Crocodylus palustris* rich area (Bhandari, 1996).

MC Eachern (1996) studied regional and seasonal characteristics of water chemistry, algal biomass and nuitrient limitation in different Lakes of Nepal including Rani Tal, Gaindawana Lake, Ghodaghodi Lake, Beeshhazar Lake and Koshi Tappu during (1993-1995). On basis of Total phosphorous and Total Nitrogen, he categorized Rani Tal as eutrophic Lake with compare to the tropic status given by Foresberg and Ryding 1987.

Lohani (2000) made detailed study on Conservation problem of SWR reported Rani Tal as rarely seen Marsh Mugger area with many spotted deer, Wild boar, Jungle Fowl with occasional Swamp deer. This place is lonely visited by the wild Elephant and Rhinoceros. He reported the rain carries silt from west of the Lake which is little bit sloppy by which, The 18 hectare of Rani Tal has reduced to the 7-8 hactre. Southern region of the Lake found highly encroached by *Phragmites karka*. Because of Massive amount of lotus growing in Lake the many Lake dependent birds get drawn. Rani Tal is good habitat of tiger. Dam was reported as the corridor for the

many wildlife particularly tiger. Four tigers were reported at once from dam site of this region.

Thapa (2007) made study on survey of parasitic and infectious diseases in wild animals and livestock in SWR found prevalence of the endemic parasites and infectious diseases in wild animals like Rhinos, Wild boars, Spotted dears, Swamp deer's and blue bulls. For the case, he also made the bacterial analysis of water quality in different water body of SWR. He found the negative bacterial growth on water culture of Rani Tal with pH range of 6-7.

Chand (2007) reported Rani Tal as the most threatened Lake of the reserves area because of the size and depth of lake is reducing due to continuous siltation and domination of aquatic flora. This problem is reducing the habitat of the migratory birds, water birds, fish along with Marsh Mugger and other wild animals that live their around the Lake.

Pokharel and Sang Ho Jun (2008) made study on A siltation and environment change of two wetlands (Rani Tal & Solgaudi Tal in the SWR, western lowland Terai, Nepal). On soil analysis, vegetation sampling and water analysis revealed that the soil type is mixed with different soil texture classes. Soil in Sal forest area of the Rani Tal is very strongly acidic and Solgaudi Tal is nearly neutral. OM and Nitrogen content in soil were low and high phosphorous in both the areas. Pokharel and Sang Ho Jun also performrd micronutrient analysis of the soil revealed that Mo, Zn, Cu and B content was low. Water pH value indicated that both the Tals were lies within the acceptable range. The DO from the Rani and Solgaudi Tal was found 8.13 mg/l considered to be favorable for aquatic life. A total of 64 species of vegetation were recorded from the surrounding habitats of the two wetlands. Out of these, 30 species were trees, 26 species were shrubs/climbers and 8 were grasses and herbs. Whereas a total of 7 mammals, 2 reptiles and 14 bird species had been recorded from the area.Their field experience indicated that the local community entered illegally in the area for fishing and fuel wood for their daily needs. The illegal human intervention was one of the serious threats of wetlands and the natural threats were siltation and vegetation succession. Therefore, to prevent the Tals from the predictable tragedy detail scientific study was needed. They emphasized that Solgaudi Tal and Rani Tal could be developed as the demonstration site for conservation education on wetland

habitats. It was essential to develop the sites as the tourist attraction and generate revenue which ultimately leads to raise the quality of life of local community.

1.4.3. Study on Invasive species in Nepal

Oli (2000) reported highest number of invasive aquatic weeds (6 sps) in Rupa Lake followed by Beganash (5 sps), Dipang (4 sps), Kasthe (3 sps), Tal Khola (3 sps), Gunde (2 sps) notable plants like *Hydrilla verticillata, Potamogaton crispus, Potamogaton pectinus, Eichonochola colona* and *Panium repens*.

Tiwari *et al*. (2005), IUCN, Nepal on Field Survey reported following common wetland invasive alien species in Nepal.

Table 2: Ecological status of alien invasive species in Nepal

S.N	Name of the species	Density (pl/m^2)	Frequency %	Coverage%
1	*Alternanthera philoxeroids*	0.12	3.33	1.28
2	*Eichornia crassipes*	0.84	83.33	10.42
3	*Ipomia aquatica*	0.33	18.81	1.80
4	*Leersia hexadra*	0.70	7.14	1.04
5	*Myriophllum aquaticum*	0.02	6.2	2.14
6	*Pistia straiotes*	0.20	6.33	0.92
7	*Ipomia carnia ssp fistulosa*	0.8	29.95	14

(Source: Tiwari *et al.* (2002-2003, IUCN Nepal)

Chhetri, (2006) made study on the impact of the invasive species on the wetland birds of the Beshazari Lake in the Chitwan district. He found about 70% of the invasive alien species coverage in the Lake has caused serious problems in the bird species. The results revealed that invasion of IASP on wetland area caused the reduction of Wetland dependent bird species and the total individuals due to substantially reduction of foraging and breeding grounds.

1.4.4 Study of Mugger Crocodile in Nepal

According to Groombridge (1982); Whitakar and Whitakar (1989); the population of the Mugger Crocodile in the CNP was estimated to be 200.

Shrestha (1983) made study on the Gangetic Dolphin and Crocodile in Karnali River system focusing on microscale study of the impact of river wildlife. He estimated

altogether 9 Muggers population in Karnali. Although the study was concentrated on the Karnali River the investigator also carried out his studies on Babai River on opportunistic basis. In Babai River he reported 12 Muggers. The Crocodiles in Babai River were found to be affected by the water use projects like irrigation and flood control. Shrestha also mentioned that Crystal clear water, Neutral water, High oxygen content, High total dissolved solids, Current velocity and deed flow, Exposed windy sand banks with steep sand bank bars inclined to angle of the 45 to 60 degree, Basking promotories of rock or elevated cliff, River broken to the sister river creating ideal islands which include zone of the escape during winter seasons, Number off feeder streams at vicinity of Main River with teeming abundance of fish population so as to supplement Shortage of fish food during monsoon, River bank free from the human activities so such as stone quarrying, logs transportation, fishing and boating activities, Loose humid sand banks and mud flats ideal for egg depend, incubation nesting etc, River bank covered with extensive vegetation to meet shade and cover needs are habitat needs for the survival of Crocodile in his report.

Mitchell and Zug (1986) reported occurrence of *Crocodylus palustris* in different wetlands of Chitwan district in study of reptiles and amphibians in Chitwan district of Nepal like Beshazari Tal, Lami Tal and Narayani river etc.

Harry *et al.* (1992/1993) made survey through out the world found availability of survey data on *Crocodylus palustris* in 6 countries where 2 countries have basic survey data and 4 countries having no survey data. They found habitat degradation and illegal hunting as main threat to Mugger Crocodile. In their survey Iran, Pakistan, Nepal, Bangladesh found to be survey not planned well but India and Srilanka found to basic survey data. According to status, In Nepal and Bangladesh habitat of Mugger found to be severely depleted and in Pakistan, India and Srilanka found to be depleted. But Iran is unknown for presence management. Protection only was made in the countries Iran, Pakistan, Nepal, and Bangladesh, and Srilanka (with restocking programme).

Shrestha (1993) on his study on crocodile from 1987 to 1989 reported the Crocodile hunting and over fishing by Rajis, Sunaha and Majhi in Karnali is main threats to the Crocodile in Karnali area. Fishing activity at the Chisapani area of Karnali River is found to be exterminating the both species of the Crocodile. In his study he found that

the tribal hunter of the Karnali first locates the nest of the Crocodile during day time. At the dead of night, they return to detect nest guarding female by a torch light along the riverbank. As reflective tapetum of Crocodiles glow due to effect of light, the poacher move near the animal. If animal does not move away they kill her and collect eggs sell at 500 NRs per egg. He also found that Crocodile hunter prefers male Mugger and Gharial Crocodile because dried penis of animals used as medicinal value and aphrodisiac.

Andrew and MC Eachern (1994) mentioned in their book “Crocodile conservation in Nepal" that, By early 1970’s Gharial and Mugger Crocodile species of the Nepal were reduced to the isolated remnants due to over exploitation prior to the protection, habitat loss, intensive fishing and more recently interference of the river courses by barrage construction. At present there estimated to be 10 Gharials in wild and 140 in captivity. Similarly estimated 120 to 150 Muggers in wild and 99 in captivity were reported.

Smith *et al.* (1994) made study on aquatic biodiversity of Karnali and Narayani river basin of the Nepal from 1993 A.D to 1994 A.D reported occurrence of the Mugger Crocodile in Karnali and Narayani river basin.

BPP (1995a) reported the presence of 20 *Crocodylus palustris* from Beeshazari Lake, Chitwan, Probably 20 or at least 15 from Ghodaghodi Lake, Kailali. Beside this the presence of *Crocodylus palustris* from Lami Tal, Mauna Tal in Chitwan and Jagadishpur reserviour, Kapilbastu. It also reported 2 dead cases from Betkot Tal, Kanchanpur, Chidia Tal from Kailali, Koitaha Tal, Kailali, Narcodi Tal, Kailali Patriyani Tal, Kanchanpur and Rani Tal, Kanchanpur supports viable population of crocodile. BPP confirmed the presence of *Crocodylus palustris* in Devi Tal, Thulo Lami Tal, Beshazari Tal in Chitwan, Ghodaghodi Tal by observation of 3, 2, 2, 2, 4 and 2 numbers of Crocodile. BPP (1995b) also mentioned 20 number of Mugger crocodile from public information from Beeshazari Lake, Chitwan. In their survey, they observed 6 Mugger Crocodile from Beeshazari Lake, Probably 20 or at least 15 from Ghodaghodi Lake, 2 dead cases from Betkot Tal. They reported 4 Mugger Crocodile in Devi Tal area Chitwan. Other Lakes like Prakashpur Ghole (Sunsari), Thulo Lami Tal, Tamor Tal (Chitwan), Jagadishpur reserviour (Mugger used to enter in reservior), Chidia Tal, Kailali; Nacrcodi Lake, Kailali; Patriyani Tal, Kanchanpur;

Betkot Tal, Kanchanpur; and Rani Tal in Kanchanpur reported as Mugger finding areas.

Sharma (1997) made study on the status of the Crocodile captative breeding in CNP under support of WWF Nepal from October 1996 to March 1997. He reported the mortality of the hatchling in breeding centre is very high. In 1996, 206 hatchlings out of 274 died within 9 month period in Gharials. In case of Muggers, the situation is even worse. Only 5 individuals are in captivity and all new 294 all new hatchlings of 1996 died. In 1997 only 5 Muggers stock in captivity and 152 Gharials in captivity. The management aspect of the project is found to be not thriving as breeding project has released 51 Gharials and 100 Muggers from 1981 to 1996. From 1986 to 1996 hatchling percentages of Gharials is 53.33% (39 eggs to 208 hatchlings) and Mugger Crocodiles have 54.28% hatchlings (304 eggs to 165 hatchlings). The survival of the Gharial from starting is found to be 22% and survival of Muggers is found to be 10.6% but the survival of Gharial in nature is 20% and Muggers have more than this. In Captitive breeding centre researcher reported that there is no control in hatchery to hatch collected eggs, No appropriate size of rearing pool, Inappropriate basking yard, No deep breeding pool, Lack of sufficient trained manpower, Low quality stagnant water in hatchling pools, Limited food supply and Financial problems. In context of Chitwan, researcher reported the cause of the decrease in number of the released Crocodiles in wild is not only the mortality, the Gandak barrage is also the cause. When an individual migrate to the India through the open door of the dam they never return to Nepal due to the high current of the disposed water. On other hand the barricaded water due to the dam covers the nesting and basking sites of Crocodile.

Thakkulla (1999) made the survey of the herpetofauna and their local uses in Ghodaghodi Lake area of the Sukhad in Kailali district reported the 36 speices of the herpatofauna. He also reported the occurrence of the *Crocodylus palustris* at Ghodaghodi Lake area.

Shrestha (2001) mentioned in his book “A Field guide to the amphibians and reptiles of the Trans- Himalayan region of the Asia’ that the population of the Mugger crocodile both in nature and captivity were estimated to be 120-150. Out of the 47 individuals in the Karnali and Babai, the population of both in the captivity and nature not increasing because of the poor management. Principle threats to Crocodiles are

incidental catch in fish nets, egg collections, egg predation by animals, habitat destruction and hunting use of the Crocodile parts for medicinal purpose (Groombridge, 1982). Largest number of Mugger Crocodile from Nepal found in the Narayani and Rapti rivers within CNP. Muggers are not believed to inhabitant Karnali River but may be found in its tributaries (Thorbjarnarson *et al.* 1992). Shrestha also mentioned that hunting of the Crocodiles is prohibitory in Nepal but this protection appears to only applying to the Gharials not enough for Muggers and which is not legal protection to out side of the National Parks and Wildlife Reserves of Nepal (Andrew and MC Eachern, 1994).

Mishra (2002) made alternative Mugger study in Karnali, Babai in Bardia National park and in CNP for his survey of the Gharial Crocodile. He made the alternate survey in 7/7 days for three times in each river area during day hours. He also reported Maximum number of 8 Mugger Crocodile in Babai River. During his survey he reported no Mugger Crocodiles in Karnali river area and maximum 9 numbers of Mugger Crocodiles in Rapti River. In total he reported Gharial population more than Mugger population in Karnali, Babai and Narayani area of Nepal.

Bogati (2003) made survey on the population status and conservation measures of the Mugger Crocodile in Lami Tal area of Chitwan district. He reported maximum number of Crocodile in the sandy soil bank due to the suitable condition for basking. Grassland and erosion bank had life signification of the Mugger. The seasonal status of the Mugger Crocodile population size and status was determined. In winter' crocodile found to be 19, in summer 16 and 15 in monsoon. Flooding, filling and siltation in the Lake was great problem.

Rai (2003) made study on the distribution of the herpatofauna in Eastern Nepal found 0.4% of occurrence of the *Crocodylus palustris* out of 702 species of herpatofauna recorded from eastern Nepal. He reported *C. Palustris* from Sunsari and Saptari of Eastern Nepal out of 130 species of reptiles reported.

Shrestha and Shrestha (2008) made assessment of herpetofauna in the SWR area by including riverbeds, forest areas, wetland and Phanta area of the Shuklaphata area. They encountered 160 reptiles with 20 different species. Among which he reported altogether 9 *Crocodylus palustris.* During his field survey he reported 2 *Crocodylus*

palustris in Kalikitch Lake area, 2 in Malumela- Chaudhara river area, 3 in Pipariya – Mahakali river, 1 in Bahuni river and 1 in nearby Rani Tal area. In the reptile survey percentage occurrence of the *Crocodylus palustris* is 8.49%. They also recorded the average p^H of stagnant water in Shuklaphata as 6.9 and average temperature of 26^oC. They focused Rani Tal, Kalikitch Tal area of the Shuklaphata areas dying out Lakes and recommend to be paid due attention. The rate of the sedimentation in the Lakes should be checked and management for the habitat preservation of herpetofauna.

WWF Nepal (2008) make monitoring on the population status and distribution of the Gharial Crocodile in Nepal focusing on the Karnali, Koshi and Babai river in CNP, BNP and KWR of Nepal reported 81 species of Gharias, 34 from Narayani river and 24 from Rapti river in CNP, and 10 individuals from Babai river. The survey also reported 17 Muggers from the Babai River sharing habitat with Gharials.

CSUWN (2009) had also recorded 12 Marsh Mugger Crocodiles and their nestling sites within Ghodaghodi Lake complex area.

From literature review it is concluded that in Nepal the study on Mugger Crocodiles are limited. Even in present study site there is no specific studied made on Mugger Crocodile.

1.5 Rationale of study

In Nepal, no more studies have been conducted on the Mugger Crocodile with reference to status of wet lands. Most of studies made from the government sides and scholars were only based on inventory basis of wetlands and biodiversity assessment of them. Among those, some selected studies being made in the Rani Tal like BPP (1995a, 1995b), MC Eachern (1996), Pokharel and Sang Ho Jun (2008) could not give all round information on Rani Tal.

As we know that Western Terai contains the diversity of the species of flora and fauna under IUCN and CITES categories for conservation (GoN, 2002b). Among them, *Crocodylus palustris* is one under vulnerable categories of CITES. From few previous studies made on Rani Tal like, BPP (1995a), MC Eachern (1996), Scot (1989), Bhandari (1996), Lohani (2000) and Chand (2007), It was reported that Rani Tal along with the Lakes inside SWR are also the major habitat for the *Crocodylus*

palustris. But studies are lacking in this vulnerable species in Rani Tal areas or even in western Terai landscape. So firstly, the Rani Tal was being selected for the study to know all round status of lake and Mugger Crocodiles depending in Rani Tal. Similarily, Rani Tal is getting invaded day by day due to the alien/native floating and surface vegetation according to Bhatt and Shrestha (1973) Suwal and Shrestha (1992) and Baral (2009). The water quality is also degrading day by day (MC Eachern 1996). As we Know water quality is determinant of organism survival and growth. Thus its time should be near to get information for status of water quality, cause of invasion, suitability of water quality for Mugger Crocodile dwelling there and their number presence with present and possible threats.

Furthermore, this research may be guideline firstly for the Lake management, preparing policy and plan for conservation of *Crocodylus palustris* to the governmental sectors, and INGOs, NGOs working in field of conservation in Western Terai. Secondly, in term of Water quality, sedimentary analysis, encroachment of invasive species and about status of *Crocodylus palustris* in the Rani Tal, this study might guideline to the researchers for further study.

1.6 Objectives of study

The broad objective of study is to assess the status of *Crocodylus palustris* at Rani Tal in SWR, Kanchanpur, Nepal.

To fulfill this broad objective following specific objectives are made:

To find population of Lake dependent *Crocodylus palustris* at Rani Tal area.

To check status and cause of water quality in Rani Tal.

To assess either water quality in support for living of *Crocodylus palustris* or not.

To identify present threats and predict possible threats to Rani Tal and *Crocodylus palustris* at Rani Tal.

1.7 Limitation of Study

Insurgency and strikes in country and seasonal weather phenomenon like heavy rainfall during the monsoon season and fog during winter disturbed the scheduled activities of the study.

CHAPTER 2

MATERIALS AND METHODS

The study was conducted for one year from June 2008 to June 2009. Seasonal water analysis was made in the Lake, for which data of monsoon season, winter season and summer season was taken after fixing the suitable sites for sampling in June 2008. For winter season, field visit was made in February, August for monsoon season and May/June for summer season. Inflow, outflow and Lake water body were reached with using boat.

2.1 Sitewise map of study area

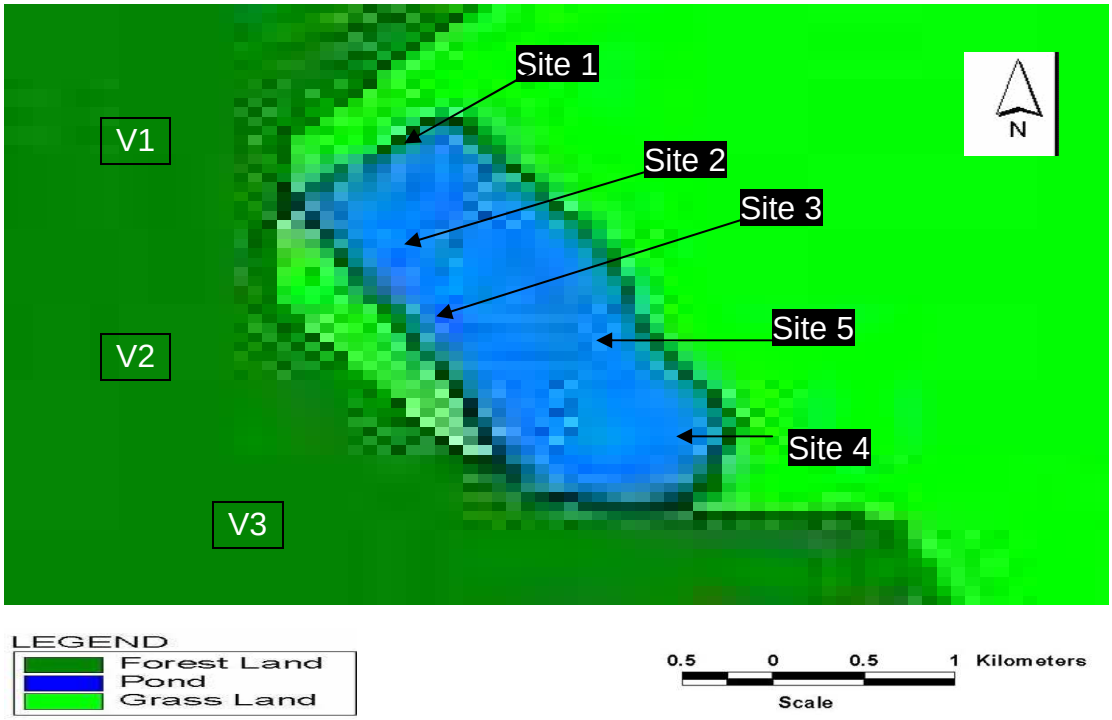

Figure 3: Sitewise map of study area

Where V_1, V_2 and V_3 are vegetation sampling sites abd Site 1, 2, 3, 4 and 5 are water sampling sites.

2.2 Methods of data collection

2.2.1 Pilot survey and site selection

Pilot survey was made in June, 2008 for the selection of sites to water sampling and possible habitats of Mugger Crocodiles in Rani Tal area. The sites like sunny place, shady place areas with comprising whole Lake body including inflow and outflow sites were sited. The inflow site and dam site were reported as good basking place of Mugger Crocodile. As its get difficult to go inside the Lake due to high plant coverage

like *Phragmites Karka* and other tall grasses in reeds and periphery. The water of somewhat open sites only was sampled.

2.2.2 Primary information

Primary information about the Rani Tal, Lakes of Shuklaphnata and Mugger Crocodile present in them and Issue related to their conservation was collected through the questionnaire survey (Annex 20).

2.2.2.1 Questionnaire survey

A well modeled questionnaire (Annex 20) was used to identify the threats to *Crocodylus palustris* at the study sites and output was drawn by interview with management members of SWR and frequent visitors from old gamescouts, peons, Army members, technical appoints and others. Total 20/20 questionnarie with non end and end types were filled up with the park members, frequent visitors for the pre information of the Muggers, its population and other status at past in Rani Tal. The questionnaire survey about 20 was also made in the ethnic community near Rani Tal area like Beldadi, Rauteli Bichuwa, and Rampur Bilaspur for knowing illegal activity.

2.2.2.2 Interviews

Interviews were made to understand status of Rani Tal and Lake dependent Mugger Crocodile with different park personnel's, army staff and previous dweller of Bichuwaphanta, Singhpur and Suryaphata together with frequent visitors from past long years. Mentioned area was not in Reserve before extension of buffer zone and SWR area. People of mentioned area are now dwelling in Beldadi and Rauteli Bichuwa areas of SWR buffer zone at Rani Tal.

2.2.2.3 Direct observation

Direct observation was made to study general background of different sites of the Lake.

2.3 Sampling methods and Sites

2.3.1 Sampling sites for water

For water sampling the inflow site, outflow site and central Lake body were sampled separately (Figure 3).

Site 1: It is the inflow site of the Lake contained high diversity of tree and *Phragmites Karka*. It is area where the Hagnia Khola flows. Hagnia Khola not contribute regular water to Rani Tal but intermittently support for water input because it has no regular flow and get dry during less rainfall period. Western site of it have forest cover and eastern site have grassland patch with high *Phragmites* grown.

Site 4: It is the outflow site of the Lake which contains dam/ an earthen embankment over 600 m long and 3 m high which help to trap a larger quantity of monsoon rain and so significantly raise the water level of the Lake. It has high coverage of the *Phragmites Karka* and many of reed beds. This included High amount of reeed beds were presented in this site. The open embankment slopes here were good basking place for Mugger crocodile.

Site 2, 3 and 5: These are area respectively western and eastern middle part of the Lake also contained of high diversity of tree and herbs along with high coverage of *Phragmites karka, Sachhrum spontanium, Imperata cyllindrica* and *Arundo donax* etc. Almost more than 80% of this site contains the high coverage of plants like *Pistia straoites, Nymphea Nouchali, Trapa quadrispinosa* and *Nelumbo nucifera* species during monsoon and summer season .The site found somewhat open during winter season.

2.3.2 Water sampling

High density plastic bottles/sampling bottles of different sizes were used for water collection. They were rinsed in water to collect water. The collected samples were left air tight so as to check the external influence. Parameters like P^H, Transparency, Total alkalinity, Hardness, DO, Free Carbondioxide and Chloride content were analysed after collection of water soon. Some parameters like Total Nitrogen, Nitrate, Orthophosphate, Total phosphorous etc were analysed in laboratory. After collecting, the sample was adjusted with concentrated Sulfuric acid less than 2 p^H and samples were preserved in ice. Collected samples were tagged and taken to lab for analysis. Similarly, for the determination of the Potassium; the sample was adjusted with p^H less than 2 of Nitric acid by following APHA, AWWA, WEF (1998).

2.3.3 Bottom sediments and Site Soil samplings

Same site of the water samplings were selected for the sampling of bottom soil. For sampling of site soil, the site soil was such collected that it would cover the water sampling area and vegetation sampling area. Bottom sediment sample were collected by using grab sampler. But, for soil sample for vegetation, soil is collected randomly below 10 cm of surfaces from different sides of the forest directely (Jackson, 1967). Samples were then collected in polythene bags. Collected soil sample was brought to the laboratory as soon as possible. After then, Soil was completely dried for 48 hour at 70 ^{0} C and stored at low temperature at short period of time. Soon after drying, stones and other materials were picked up and grinding was made in a grinders taking care that no breaking of the actual soil particles will take place. The textural analysis was made by standard methods. Soil is then passed through 2 mm sieve for further analysis of physicochemical parameter.

2.3.4 Vegetation Sampling

Same site of the water sampling was selected for the sampling of the vegetation which encompasses Site 1, 2 and 3 comprising most of water samplings area. Site 1 comprised the NW area of inflow site of the Lake, Site 2 and 3 comprised of the western and south western area of Lake. Eastern site forest of Lake was difficult to reach due small patch of grassland covered heavily with *Phragmites karka* hence was not considered for vegetational analysis. Here tree analysis was made in all three sites, climber analysis in 2 sites, floating vegetation analysis in 3 sites, marsh vegetation analysis in 2 sites.

Data collection was made with quadratic method to analyze the vital statistics of forest. The stratified random sampling method was used in all transects. Analysis on the floral diversity of each quadrate was carried out in randomly laid quadrates. Requisite size and number of the quadrates were determined by species area curve method (Mishra, 1968). Parameters like coverage were determined by scale proposed by Daubermine (Daubermine, 1968).The data collection for frequency, abundance, coverage dominance and diversity of native and alien invasive species and surrounding vegetation were made on basis of standard methods given by (Zobel *et al*.1987 and Odum, 1986). Qudrate size was determined by using species area curve. To make the study the quadrate of size 30 m x 30 m for trees, 1 m x 1m for grassland herbs /Marsh vegetation were laid down. Ecological survey was also carried out to

find out current status of the IAS. The quantitative data of IAS such as density, frequency and converge were collected randomly by quadrate sampling methods with all floating plants using quadrate size 50 cm x 50 cm**.** For marsh vegetation and Floating species of plant, almost 10 quadrates were laid down in each site and their average was taken to calculate quantitative characters. Same site of tree sampling was used for sampling of climbers within same quadrate.

Most of the plant species were identified at the field with the help of local names provided by local people and standard reference (Stainton and Polunin, 1987; Stainton, 1988 and Shrestha, 1998). Unidentified species were collected, tagged and identified by consultation with taxonomist correct scientific names and other citation were made with the help of Hara *et al.* (1978), Hara and Williams (1979) and Press *et al.* (2000). The invasive plants were identified with help of reference books (Tiwari *et al.* 2005) and suspected unidentified species were pressed under herbarium and taken to lab for analysis by reference books and experts.

2.3.5 Water analysis

All the physicochemical parameters (except Total Nitrogen) determined according to the methods described in APHA, AWWA, WEF (1998). The Total Nitrogen and Total Phosphorous were determined as the method prescribed in the Trivedi and Goels (1986).

2.3.5.1 Color

Procedure: The color was directly observed by taking water sample in a Petri dish above white paper.

2.3.5.2 Temperature

Procedure: The temperature of the Lake was measured by dipping the bulb of a mercury thermometer in water. At surface, three observations were made at 30 minutes time interval to obtain the accurate temperature and the average water temperature was obtained. The temperature was measured on the Celsius scale.

2.3.5.3 pH

Procedure: For measuring the pH value a beaker was filled with the collected water and the battery operated pH meter (pH -j-251w griffin) was dipped in the beaker up to the level marked in the pH meter and reading was noted.

2.3.5.4 Electrical conductivity

Conductivity is the measure of the capacity of substance or solution to conduct the electric current. Conductivity is highly dependent on the temperature and therefore is reported normally at 25 ^{0}C.

Procedure: The instrument used to measure the conductivity of the water sample was a digital conductivity meter (Model 4150 by watgech and accuracy of ± 5%) The instrument was first brought in conductivity mode then the electrode was washed with distilled water and then dipped in to beaker containing the water sample. The conductivity reading was noted down after reading stabilized certain point.

2.3.5.5 Transparency

Procedure: The transparency of the water was measured by using a Sechhi disc of 20 cm diameter divided in to black and white quadrants. The disc was lowered in water and the just point where it disappear was noted. The disc was further lowered and began to rise and the point where just it reappear was noted. The distance was calculated with help of those marked points and transparency was calculated as

$$\text{Sechhi disc transparency (Cm)} = \frac{A+B}{2}$$

Where A = Depth at which Sechhi disc just disappear

B = Depth at which Sechhi disc just appear

2.3.5.6 Dissolved Oxygen

Procedure

Winkler's Method: The basic concept of the iodemetric method is to bind the Oxygen in the water with which Iodine which is released as result of the chemical reactions the chemically bound DO is quantitatively measured by titration with Sodium thiosulphate.

The DO was determined by the standard Wrinkle's method. The sample water was filled in the BOD bottle (glass stopper bottle) of known volume (300ml) avoiding any kind of bubbling and trapping of air bubbles in the bottle after placing the stopper. In this sample water 2 ml of each $MnSO_4$ and alkaline KI solutions were poured and formed the precipitation. Now placing the stopper, the BOD bottle was shaking so that the contents would invert the bottle repeatedly. The bottle was kept for sometimes to settle down the precipitate and then about 2 ml of conc. H_2SO_4 was added to dissolve the precipitate by shaking the content well. Now, 50 ml of content of BOD bottle was titrated with standard Sodium thiosulphate (0.025N) using starch as an indicator. At the end point, initial dark blue color changes to colorless. The DO can be estimated by using the formula.

$$DO \text{ (mg/l)} = \frac{(ml \times N)\ of\ titrant \times 8 \times 1000}{V_2 \times \left(\frac{V_1 - V}{V_1}\right)}$$

Where, N = Normality (Strength of Sodium thiosulphate)

V_2 = Volume of content titrate

V_1 = Volume of sample bottle (BOD bottle

V = Vol. of $MnSO_4$ and KI added

2.3.4.7 Free Carbon dioxide

Procedure: The amount of free CO_2 can be determined by the titration of the water sample using strong alkali such as NaOH (Sodium hydroxide) to pH 8.3. At this pH all the free CO_2 is converted to the bicarbonates. The completion of the reaction is indicated by the development of the pink color characteristics of the phenolphthalein indicator at the equivalence pH of the 8.3. For this, 50 ml of the sample was taken in the conical flask and few drops of the phenolphthalein indicator were used. Then it was titrated against 0.05 N NaOH.

Calculation

$$\text{Free } CO_2 \text{ (mg/lt)} = \frac{(ml \times N)\ of\ \ NaOH\ \times 1000 \times 44}{V}$$

Where, V = Volume of water sample taken (ml)

N= Normality

2.3.5.8 Total Hardness

Procedure: Hardness is caused by the calcium and magnesium ions present in water. Total hardness of water was determined by EDTA method.

First 50 ml of water sample was taken in a conical flask and it was added by 1ml of buffer solution with Erichrome Black-T indicator. Then, it was titrated against standard EDTA (Ethylene Diamine Tetra Acetic Acid). The solution was changed wine red to blue at the end point. The working formula is

$$\text{Total Hardness as } (CaCO_3) \text{ mg/l} = \frac{\text{ml of EDTA used x100}}{V}$$

Where, $V =$ volume of water sample taken (ml)

For calcium and Magnesium Hardness

50 ml of the water sample was taken in the flask and 2 ml of NaOH (1M) solution was added. A pinch of the murixiode indicator was added on it and the solution thus formed was titrated with 0.01M EDTA immediately until the pink color changes to the purple to determine the end point.

Calculation

$$\text{Ca hardness as } CaCO_3 = \frac{\text{Volume of 0.01M EDTA used}}{\text{Volume of the sample taken}} x1000$$

Magnesium hardness as $CaCO_3$ = Total hardness - Calcium hardness

2.3.5.9 Total alkalinity

Procedure: Total alkalinity is the measure of the capacity of the water is to neutralize a strong acid. The alkalinity in the water is generally imparted by the salts of Carbonates, Bicarbonates, Phosphates, Nitrates, Borates, and Silicates etc together with hydroxyl ion in free state.

Total alkalinity of water was determined by Titrametric method.100 ml of sample in a conical flask with 2-3 drops of methyl orange was titrated against standard, 0.02 N H_2SO_4. At the end point, yellow color was changed to pink color.

Calculation

$$\text{Total Alkalinity (mg/l)} = \frac{a \times N \times 1000 \times 50}{V}$$

Where, $a =$ Volume of standard H_2SO_4 used in titration.

$N =$ Normality of H_2SO_4 used.

$V =$ Volume of water sample taken (ml)

2.3.5.10 TDS, TSS and TS

Procedure: The desired sample was taken and filtered with help of Hotman's filter paper before which filter paper was dried and kept in desiccators for absorption of the moisture. The initial weight of it and weight with residue was also measured. It was oven dried at 180 degree for few hours. The final weight after drying was also taken, the difference between final weight after drying and the initial weight of the filter paper gives the value of Total Suspended Solids. Total Dissolved Solids are determined by the residue left after evaporation of the filtered sample. For this, the clean crucible was oven dried and initial weight was taken after cooling in desiccators .The sample was filtered and desired amount of filtrate sample was put in crucible. The filtrate evaporated to dryness and again weighed. The difference between the initial weights of crucible with final weight after drying to evaporation gives the value of Total Dissolved Solids

Finally the total solid is determined by adding the value of Total Suspended Solids and Total Dissolved Solids.

Calculation

$$\text{Total Suspended Solids (TSS)} = \frac{(b-a)\,x\,1000x1000}{(\text{Volume of sample(ml)})}$$

$$\text{Total Dissolved solids (TDS)} = \frac{(d-c)\,x\,1000x1000}{(\text{Volume of sample(ml)})}$$

Total Solids (TS) =TSS+TDS

Where,

a=Initial weight of Filter paper

b=Final Weight of Filter Paper

c=Initial weight of Crucible or Porcelein basin

d=Final weight of Porcelein basin or Crucible

2.3.5.11 Total Nitrates (NO_3^-) or Nitrate- Nitrogen

Phenol disulfonic Acid method Procedure: 50 ml sample was taken in conical flask and then equivalent amount of Silver Sulphate (1 mg/l Cl^- = 1 ml Ag_2SO_4 solution) was added to remove Chloride. Then the content was heated slightly and the precipitation was filtered if formed. Then the filtrate was evaporated to dryness. The residue was cooled and dissolved by adding 2 ml Phenol Disulphonic Acid and the content was diluted to 50 ml. 6ml of liquid Ammonia was added to develop yellow

color then the reading was taken at 410 nm. Then the concentration of Nitrate was calculated from the standard curve.

Preparation of standard curve: Standard curve for the absorbance of Nitrate at different concentration were made by diluting the stock solution of different strengths. To 50 ml of each dilution, 6 ml liquid Ammomnia was added to develop yellow colors.

2.3.5.12 Total Phosphorous

All forms of the phosphorous whether wether dissolved or particulate are converted to inorganic forms after digestution of oxidation of sample. H_2SO_4 - HNO_3 technique of digestion was used for digestion of sample.

H_2SO_4 - HNO_3 method:

1. 25 ml of sample was taken in Kjeldhl flask of 100 ml.
2. 1ml of H_2SO_4 and 5ml of $HNO_3$was added.
3. The sample was digested in heater till the volume becomes nearly 1 ml and heating continued further until solution becomes colourless after removal of HNO_3.

Estimation of Phosphorous

1. 20 ml of distilled water with 1 drop of penopthelein to the digest was added. The acid was nuetrialized by titrating with 5N NaOH till pink colour was obtained. Further methods were adopted same as inorganic Phosphorous estimation.

Ammonium Molybdate Method

50 ml of water used to wash dried sample and taken in a conical flask, and then 2 ml of Ammonium molybdate was added and followed by 5 drops of $SnCl_2$ solution. Blue color appeared the reading was taken at 690 nm on a Spectrophotometer using distilled water blank with then same amount of chemicals. The reading was taken after 5 minutes but before 12 minutes of the addition of reagents. The standard curve was prepared between the concentration Vs absorbance. Then the concentrations of phosphate in the samples were noted down by using the standard curve.

Seperate standard curve for total Phosphorous after the digestion of various dilution of standard solution because chemical used in digestion may affect intensity of developed colour.

2.3.5.13 Biological Oxygen Demand (Five-Day BOD Test)

Procedure: This is an empirical, semi-quantitative method, based on oxidation of OM by suitable microorganism during a 5 day period performed as follows.

Preparation of dilution water: One liter distilled water was taken in a volumetric flask and 1 ml of each Phosphate buffer, Magnesium Sulphate, Calcium Chloride, and Ferric Chloride was added and mixed thoroughly.

Sample preparation: 50 ml of water was taken in a 1000 ml volumetric flask and diluted to 1 liter by using 950 ml of dilution water and then mixed thoroughly. Then the initial DO was calculated and the diluted sample was incubated at $20^{o}C$ in and incubator (Sanyo incubator, Item no. 10) for days to determine its final DO.

Calculation:

BOD (mg/l) = (DO_1-DO_5) x dilution factor

Where, DO_1 = Initial dissolved oxygen during dilution

DO_5 = Final dissolved oxygen after 5 days incubation

2.3.5.14 Orthophosphate

It was determined with Ammonium Molibdate method as follows.

Procedure: 50 ml of water sample was taken in a clean conical flask. The colloidal impurities and color content were removed by adding a spoonful of activated charcoal prior to filtration. Then, 2 ml of Ammonium Molybdate was added to the filtrate followed by the addition of five drops of Stannous Chloride. The absorbance was noted within 5 to 12 minutes after the addition of the last reagent. Then the organophosphate concentration of the water sample was obtained by using standard curve.

Preparation of standard phosphates solution: 4.388 grams of dried anhydrous Potassium Hydrogen Phosphate (KH_2PO_4) was dissolved in distilled water to make up a volume of 1 liter. 10 ml of this solution was diluted to 1000 ml (i.e. 100 times) to make the standard phosphate solution of concentration 10 mg/l.

Preparation of standard curve: A standard curve for the absorbance of phosphate at different concentration was made by diluting the stock solution at different strengths. To 50 ml of each dilution, 2 ml Ammonium Molybdate and 4 drops of Stannous

Chloride solution were added. The absorbance of each solution, after the development of blue, was measured within 5 to 12 minutes after the addition of the last reagent at 690 nm in the Spectrophotometer.

2.3.5.15 Primary productivity

Procedure: The Oxygen measurement method i.e. "Light and Dark bottle method" was used to determine the primary productivity of the Lake.

Three BOD bottles labeled as light bottle, Dark bottle and initial bottle were taken. All were filled with water sample. The light and dark bottles were left in the water for four hours and the DO content o the initial bottle was immediately determined by Winkler's method. At the end of four hours, the light and dark bottles were removed from the water and the DO of these bottles was determined.

Calculations

$$\text{GPP (gm.C.m}^2\text{/hr)} = \frac{\text{LB - DB}}{\text{Incubation period}} xF$$

$$\text{NPP (gm.C.m}^2\text{/hr)} = \frac{\text{LB - IB}}{\text{Incubation period}} xF$$

Where,

GPP= Gross Primary Productivity

NPP= Net Primary Productivity

LB = DO in Light bottle (mg/L)

DB = DO in Dark bottle (mg/L)

IB = DO in Initial bottle (mg/L)

F = Ratio of molecular masses of Carbon and Oxygen (=0.375)

2.3.5.16 Total Nitrogen

Procedure: About 40 ml of water sample was taken in a 100 ml Kjeldahl Flask. To the sample, 4 ml H_2SO_4, 0.3 ml $CuSO_4$ solution, 6 gm of solid Potassium Sulphate and 1 ml of 10 % NaCl solutions were added. The flask was heated on a heater to avoid loss through foaming. When the color of the content turned pale green, the heating process was continued for additional 30 minutes. The flask was cooled and the volume was diluted to 100 ml. 25 ml of the content was kept for distillation after the addition of 10 ml of 10 N NaOH. The distillate was titrated (in Boric acid + Mixed Indicator) with 0.01N HCl until the color changed from blue to brown or faint pink.

Calculation

$$Total\ Nitrogen\ (mg/l) = \frac{(a-b)\ X\ 0.01\ X\ 1000\ X\ 14\ X\ D}{Volume\ of\ sample\ distilled}$$

Here, a = ml of HCl used with sample

b= ml of HCl used with blank

D= dilution factor (2.5)

2.3.5.17 Sodium

Procedure: The water sample was filtered with the help of filter paper (Whatman's 52) and the emission intensity (read out) was measured. Then the Sodium concentration in water determined with the help of standard curve.

Preparation of standard Sodium solution: 2.542 gm of NaCl dried at 140^0C was taken and diluted to 1000ml with distilled water.

Preparation of standard curve: A standard curve of Sodium at different concentrations was made by diluting with the help of Flame photometer (Models PFP 7 and PFP 7/C, Wagtech International Ltd.) and the corresponding read out was noted.

2.3.5.18 Potassium

Procedure: Trace amounts of potassium can be determined in either a direct reading or internal standard type of flame photometer at wavelength of 766.5 nm. The water sample was filtered and the potassium content present in it was determined with the help of read out (obtained from the Flame Photometer) and the standard curve.

Preparation of standard Potassium solution: 1.907 gm of KCl dried at 110^o C was taken and diluted to 1000 ml with distilled water.

Preparation of standard curve: A standard curve of Potassium at different concentration was made by diluting the standard solution at different strengths. These concentrations were measured with the help of Flame Photometer and the corresponding read out was noted.

2.3.5.19 Total inorganic Arsenic

Total inorganic Arsenic was determined by following methods

Procedure: 5 ml sample was taken into the Arsine generator and 5 ml conc.HCl, 2 ml KI solution and 8 drop 0.4 ml $SnCl_2$ reagent; sample was mixtured thouroughly after each addition and kept for 15 minutes. Glass wool was socked in scrubber with lead acetate solution taking care that the solution does not drain into the generator. Then, the 4 ml Silver diethyl dithiocarbonate reagent in the absorber tube was taken. 3 gm of the Zinc was added in the generator and immeadetely connect assembly with all the air tight. It was kept about 30 minutes for generation of Arsine with slight heating of generator. The gas will be observed at SDDC reagent. The solution was now removed from the absorber and measured the intensity of colour at the 535 nm using reagent blank as reference. The standard curve was prepared in range of 20.0 microgram to 100.0 microgram. The calculation was directely done from calibration curve.

2.3.5.20 Chloride

Chloride was determined by titrimetric method. It was done by titrating 50 ml of sample containing 4-5 drops of $K_2Cr_2O_7$ indicator with Silver nitrate (0.014). The indicator produced light yellow colour which converted to brick red at end pont. The Chloride was calculated as

$$Chloride\,(mg/lt) = \frac{(ml\ x\ N)\ of\ \ AgNO_3\ x\ 1000\ x\ 35.5}{Volume\ of\ \ sample\ used}$$

2.3.6. Bottom and Site Soil analysis

2.3.6.1 Soil pH

50 mg of soil was taken and some distilled water with dilution about 1:5 was made and it was stirred for one hour to make the uniform mixing of the material and then directly measured by pH meter (Trivedi and Goel,1986).

2.3.6.2 Soil Conductivity

1:5 soil suspensions with distilled water were made and conductivity measure was made so that microbial activity could not affect it. Conductivity was directly measured with dipping it on suspension of soil made.

Conductivity = Observed conductance x Cell constant x Cell factor

Conductivity expressed at 25 ^{0}C specifying dilution of soil sample.

2.3.6.3 Soil Texture analysis

Soil texture is defined as the relative proportion of various size groups of individual soil particles. The soil analysis was made by Bouyoucos (1927) ie: Hydrometric method. For this the oven dried soil sample was grinded in Mortars and sieved sample was taken in to 250 ml of beaker. 20 ml of Sodium hexaphosphate $Na_6 (PO_3)_6$ was poured. The solution was treated to break the soil crumbs. Further sufficient water was added to make the about 2/3 rd of the beaker. It was stirred well and left for night in room temperature. Next day, by the electrical stirrer it was stirred for 5 minutes. Then, the whole solution was transferred into the Hydrometer jar (1000 ml) and the volume was made-up to the mark by adding extra water. The jar was shaken upside down several times. Hydrometer was dipped immediately on the top of soil suspension and the initial reading was noted after 40 sec. The second reading was taken after 2 hours.

Calculation:

Hydrometer reading at 40^o C

Silt % + Clay % = First reading in 40 sec x (Correction coefficient) x 2

Hydrometr reading at 2 hours

Clay % = (Second reading in 2 hours x (Correction coefficient) x 2

Silt %= (Silt % + Clay %) - Clay %

Sand =100 - (Silt % + Clay %)

Finally knowing the % of the Sand, silt and clay the soil texture was determined from the "International triangular Chart" used by United State soil survey Department (1969).

Soil particle size group are as follows:

Table 3: Soil Texture Classification

Soil Texture	**Size**
Coarse gravel	>5 cm
Fine gravel	2 mm to 5 cm
Coarse sand	0.2 mm to 2 mm
Fine and	0.02 mm to 0.02
Silt	0.002 mm to 0.02 mm
Clay	<0.002 mm

It was determined by simple method.

The percentage values of Sand, Silt and Clay were calculated as:

Sand fraction = Level of soil settle out for 40 second.

Silt fraction = Level of soil settle out in 6 hours-Level of soil settle out for 40 sec.

Clay fraction = Level of soil in the jar-(fraction of sand and silt)

2.3.6.4 Soil organic Mater for Bottom and Site soil

The surface soil analysis, just below surface about 10 cm was done to determine either runoff from surrounding soil contributing to the Rani Tal for eutrophication or not. For the estimation of the OM content of the soil was made through Walkley and Black's method (modified) as Trivedi and Goels (1986).

Procedure

The clear dried soil was taken and passes through the sieve of non ferrous screen of 0.5 mm. 1 gm of soil sample was transferred in to the dried 500 ml conical flask and 10 ml of the 1 N $K_2Cr_2O_7$ solution and 20 ml of the Conc. H_2SO_4 which was mixed by Swirling.

Mixture was kept to react for 30 minutes. After the reaction was over, the content was diluted with 200 ml of the distilled water and 10 ml phosphoric acid. It was followed by 1 ml of diphenyl amine indicator.

Titratation was made with the sample with 0.4 N ferrous ammonium sulphates. At the end point, color changes to brilliant green. If more than 8 ml of the 10 ml added $K_2Cr_2O_7$ is consumed (ml titrant less than 5 ml) the less quantity of sample was repeated. The system is run for the same quantity of sample without soil.

Calculation

a. % carbon= $\frac{3.951}{g}(1\frac{T}{S})$

b. OM = % C x 1.724

Where, g =Weight of soil sample in gm

S = ml ferrous solution with blank titration

T = ml ferrous solution with sample titration

2.3.6.5 Moisture Content

The fresh weight of the soil was taken immediately. The soil was oven dried at the temperature of 110^0 C for 24 hrs. It was weighed again to obtain the dry weight of the soil.

Working formula:

I. Moisture content of the soil= $\frac{Fresh\ .wt\ -\ dry\ .wt\ .}{Fresh\ .wt} \times 100$

2.3.6.6 Water holding Capacity of Soil

The water holding capacity of each soil sample was determined as method adopted by Kopecky and Burger (1974).

100 gm of soil was taken in already weighed perforated Cane at bottom of which a filter paper was placed. Then sufficient quantity of water was added on soil. Then, it was left in tray containing water. After 2 hours, outland extra water was removed from saturated soil by means of blotting paper and weight was recorded. The water holding capacity was recorded and calculated by formula.

$$\text{WHC (\%)} = \frac{(A - B)\, x100}{B}$$

Where A = Weight of Moisture retained Soil

B = Dry weight of soil

2.3.6.7 Total Nitrogen

Kjeldahl digestion method was used to determine the Nitrogen content in soil. Kjeldahl method measures only the Nitrogen in form of ammonium and organic Nitrogen excluding Nitrate composition. Here, the soil was digested with concentrated Sulphuric acid in presence of catalyst. As the proper digestion takes place at higher temperature (360-400^{o}c). Sodium sulphate is added to raise the boiling point of the sulphuric acid. Finally after digestion, the Nitrogen is converted in to the Ammonium sulphate and can be determined after distillation in alkaline condition.

Procedure: 1 gm of peaty soil was taken after passed through 0.15 mm screen in to 300 ml Kjeldahl flask. 20 ml distilled water was added to moisten the soil. After this 20 gm of the catalyst mixture and 35 ml of Conc. H_2SO_4 was mixed with gentle swirling. Initially, it was heated at low temperature. Digestion was continued and flask kept rotating at interval until the content becomes light yellow. Flame should not be allowed to touch the upper part of the flask with level of the contents avoid any undue loss of the NH_3 by decomposition of the Ammonium sulphate by higher temperature. It was heated further to releases all residual Nitrogen. The digest prepared was thus cooled, by adding 100 ml of the water distilled, mixing thoroughly and transferred the supernatant in 1 liter of the distillation flask, about 4-5 times washing with about 50 ml of distilled water and transferred the supernatant in same distillation flask leaving behind as much as possible. This will prevent the bumping in

the distillation flask. 100 ml of the 40% NaOH and few pieces of the zinc were added to distillation flask to avoid the stopping heat to prevent back sucking. The mixed indicator in condensate turns blue due to the dissolution of Ammonia. The content was titrated with 0.1N HCl until though color change to light brown pink.

Calculation

a. When whole digest has been distilled

$$\% N = \frac{(a - b) \times N \text{ of } HCl \times 1.4}{s}$$

b. when only the part of digest has been distilled

$$\% N = \frac{a - b \text{ of } HCl \times 1.4 \times V}{v \times s}$$

2.3.6.8 Exchangeable potassium

Exchangeable potassium and Sodium were determined with flame photometry method (Trivedi and Goel, 1986)

Procedure: Flame photometry was used to deternmine extractable Sodium and potassium content. Here, the soil extract was prepared by leaching with 1N Ammonium acetate. 50 gm of the air dried soil was taken in 500 ml beaker and 1000 ml of 40% alcohol was added. It was shaked well and kept for 15 minutes. The suspension was filtered through Whatmans No. 50 filter paper using Buchners funnel and vacuum pump.The soil was washed 4-5 times with 50 ml portion of 40 % alcohol. The final washing was performed with 50 % of absolute alcohol to dry the soil.Then the filter paper was removed and soil was scrapped in 250 ml of beaker. The Buchner funnel and filter paper was washed with 100 ml Ammonium acetate to remove any adhered portion of soil. The suspension was stirred and kept for whole night. The supernantant was filtered and the soil with additional ammonium acetate was filtered through Whatmans No. 42 filter paper using Buchheners funnel and Vacuum pump. The soil was leached 4-5 times more with portion of Ammonium acetate and final volume of the filtrate was made up to 5000 ml in volumetric flask. Same procedure followed further what have been followed for Sodium and Potassium detection in water analysis.

2.3.6.9 Orthophosphate

Phosphorous in soil is generally determined as available Phosphorous, which can be extracted from soil with 0.002 N H_2SO_4 (1 Soil: 200 H_2SO_4). The Molybdenum blue

method is most sensitive and as a result, they are widely used for soil extracts containing small amount of Phosphorous as well as Total phosphorous determination in soils.

Procedure: Fresh soil was taken and passed through the 2 mm sieve size. Moisture content was detemined by oven drying at 105 ^{0}C. The fresh soil sample equivalent to the 1.0 gm oven dry soil in a 500 ml Conical flask and 200 ml of 0.002 N H_2SO_4 was taken. The suspension was shaked for half an hour. The soil solution was filtered to get the clear soil solution. Then same method was applied as done for Orthophosphate determination in water.

Calculation:

$$\% \text{ available p} = \frac{mg\ \ P / L\ soil\ \ solution}{50}$$

2.3.7 Quantitative Data analysis for Vegetation

2.3.7.1. Density, Frequency and coverage of Plant Species

Density is the number of individuals per unit area. It represents the numerical strength of the species in the community. It is usually expressed as number of plant per hectare (pl/ha).

Frequency as introduced by Raunkiaer (1934) indicates the number of sampling units in which the particular species occur, thus expresses the dispersion of various species in a community. The frequency refers to the degree of dispersion of a species in terms of percentage occurrence. It is expressed in percentage.

Ecological data were interpreted by using standard methods given by Zobel *et al.* (Zobel *et al*. 1987; Odum, 1996).

$$Frequency\ \ \% = \frac{No\ \ \ of\ \ plots\ \ in\ which\ \ species\ \ occured}{Total\ \ number\ \ of\ \ plots\ \ studied} x100$$

$$\text{Density (D)} = \frac{No.\ of\ \ individuals\ of\ a\ species\ in\ all\ plots}{Total\ \ number\ \ of\ \ plots\, studied\ \ x\, size\, of\ the\ \ plot} \times 10000$$

Frequency was nominated with Raunkiers frequency class (Appendix 4). Coverage was estimated by visual estimation on percentage basis.

Relative frequency, Relative density and Relative coverage was determined by following method formula.

$$RF = \frac{\text{Frequency value of particular species}}{\text{Total frequency of all species}} \times 100$$

$$RD = \frac{\text{Density value of particular species}}{\text{Total Density of all species}} \times 100$$

$$RC = \frac{\text{Coverage value of particular species}}{\text{Total coverage of all species}} \times 100$$

For small scale plots visual estimation method was reliable hence, Visual assumption method was used to calculate coverage value.

2.3.7.2 Index of Dominance

Those species which have strongest control over energy flow and the environment in given habitat are known as ecological dominants. Simpson (1949) has given the following formula to estimate the index of dominance.

$$Cd = \sum \left(\frac{ni}{N} \right)^2$$

Where, ni = Importance value of the species

N= Total importance value of all the species

2.3.7.3. Index of Diversity (H)

Species diversity index is the ratio between the number of species and importance value of individual (Odum, 1996). It is important to recognize that species diversity has a no. of components, which may respond differently. Major components are species richness or variety component and species evenness or equitability. The following formula is used to calculate index of diversity (Zobel *et al.* 1987)

$$\text{Shannon index (H)} = -\sum \left(\frac{ni}{N} \right) \log_e \left(\frac{ni}{N} \right)$$

Where, ni = Importance value of each species

N= Total importance value of all species

2.3.8 Litter collection and analysis

For the collection of litter, the area of 50×50 cm^2 was fixed in each sites. Then all the litters within the area were collected and were kept in the sample bag. To ensure not to loose any moisture content, the sample bag was packed by rubber band and was

brought into the lab after tagging it. Altogether 3 samples from each site were collected. The biomass analysis and moisture percentage was calculated. The sites were correlated with the adding factors for water in Rani Tal area.

2.3.9 Population and Threat identification of Marsh Mugger

Crocodilians being amphibians in nature can be counted both on land and in water. Crocodiles basking on land during day time are easier to count and estimate the size. The best season for the Crocodile survey is in post winter and pre summer i.e. January to March (Rodgers, 1991). During this period the temperature conditions are such that Crocodiles bask longer period and the visibility is good for sighting. This is the courtship season and breeding groups tend to bask in the groups. Air temperature, day length and availability of sunlight for basking greatly influence the amount of time Crocodile can bask on shoreline. Winter month therefore are good times to count Crocodile during day time (Choudhary and Roy, 1982; Rodgers, 1991).

Crocodile counting was made in winter. The best season for the Crocodile survey is post winter and pre summer month ie. January to March. During this season, the temperature conditions are as such that Crocodiles bask for the longer period of time and visibility is good for the sighting. This is also the courtship season and breeding groups tend to bask in the groups. Therefore Field trips were made continuously for 15 days in February together with nature guide and group of friends. Transect walk was made on foot in Rani Tal surrounding. Population census in Rani Tal was carried out by direct observation. Survey was conducted along Lake side using direct observation method from short distance with the help of binocular from relevant height. Possible basking places were visited time to time for finding real survival status. Pug marks and scats looked. The counting operation was kept on hold whenever day was foggy, adverse condition for basking. The binocular 8×40 magnification was used in population count as visual aid. Visual observations are made from the viewing towers and from the high trees. To avoid the double counting different natural features were used at same time with help of assistants together with local staffs, nature guides (Rodgers, 1991). The parameters such as time and location of sighting, activity of sighting animal, weather condition, habitat conditions, water status was also recorded with Crocodile data. During transect walk, the rustling of the leaves litter area might cause animal to run away thus it was cared and too much care was made in the walking so as not having conversation and using sign language with

assistants. The entire bank of the Rani Tal has been divided into the following 5 sectors based on the composition of soil and vegetation (Maskey, 1989; Maskey *et al*, 1995: In Bogati, 2003) to make counting easy.

a) Mud bank (MB) -The bank of Lake covered by the mud.

b) Sandy soil Bank (SSB) - It is the bank consists of sand mix with black soil.

c) Sandy grass bank (SGB) -The grass is not densely on the sandy soil area known as sand grass bank.

d) Grass bank (GB) - The bank of the Lake covered by dense grass bank.

e) Erosion bank (EB) - The bank consists of the only water erosion prone area.

The size estimation was made on visual basis and classified as following basis (Rodgers, 1991).

Hatchling (< 50 cm), Yearling/Juveniles (50 -120 cm), Sub adult (120-180 cm), Adult (>180 cm), Eyes only (for very far or difficult to estimate)

The threats of Crocodile were determined as direct and indirect threats. Since Crocodile is semiaquatic animal, the direct threats were determined on the basis of comparing the obtained water quality data with the water quality criteria given for the semiaquatic animals or for Mugger Crocodiles. Similarily other threats counted on visual basis were also made. Vegetation analysis, Soil analysis was also related with threat directely and indirectely to Lake/ Crocodile. The Mugger Crocodile feed upon the large variety of diet from small animals to even large mammal. So, indirect threats were determined by the quality of water comparing with the criteria given for fish, amphibians, reptiles and many of animals aquatic or Terrestial or semiaquatic animals.

2.4. Secondary information

Secondary data were collected from various published reports and unpublished documents, thesis reports, project documents, internet documents, environmental journals, policies, laws, commentaries and opinion appear on secondary sources. The climatic record was obtained from DHM of GoN. Other secondary information were generated from the variety of matter from WECS, DHM, ICIMOD, TUCL, IUCN, WWF, NTNC, DNPWC , MOFSC, NARC, NAST, CDES.

2.5 Methods of data analysis

Collected information was presented in the appropriate tables and charts.They were categorized and tabulated according to objectives of the research. Data was manually processed and analyzed in descriptive ways using different statistical tools. MS Excel 2007 was used in analysis.

CHAPTER- 3

RESULTS

3.1 Water quality- seasonal and sitewise physicochemical parameters

3.1.1 Color

Color reflects slight variation throught year. Green color of Lake water was observed in summer and winter but during monsoon season somewhat muddy green color was reflected. In total, light green to the green colour to somewhat yellow green colour was reflected during year. This might be due to the growth of algae and and addition of mud from the flooding water. According to the BACH (1980) index for the water quality, the colour present in the Rani Tal showed it was moderate to be severely polluted.

3.1.2 Seasonal pH values of Rani Tal

As shown in figure 4, average pH of Rani Tal was found to be 7.17 during winter season. Monsoon season had average pH of 7.2 with highest pH value of 8 at Site 4. Sites 1, 2 and 3 respectively showed the pH values of 7.2, 7.2 and 7. During winter season, the lowest pH value of 6.6 was found at Site 5. High value of hydrogen ion concentration was reported at Site 1 with 7.39 and at Site 3 of 6.91. Site 2, Site 4 and Site 5 showed pH value of 7.13, 6.92 and 7.5 during winter season. Similarly, In summer season, average pH is 7.3 with highest pH value at Site 4 of 8.2 followed by Site 1 of 7.9. Site 2, Site 3 and Site 5 showed respectively 6.7, 6.4 and 7.2 pH values. pH of monsoon, summer and winter ranged from 7-8, 6.4-7.9 and 7.13-7.5 pH value respectively (Figure 4, Annex 10,11,12,13)

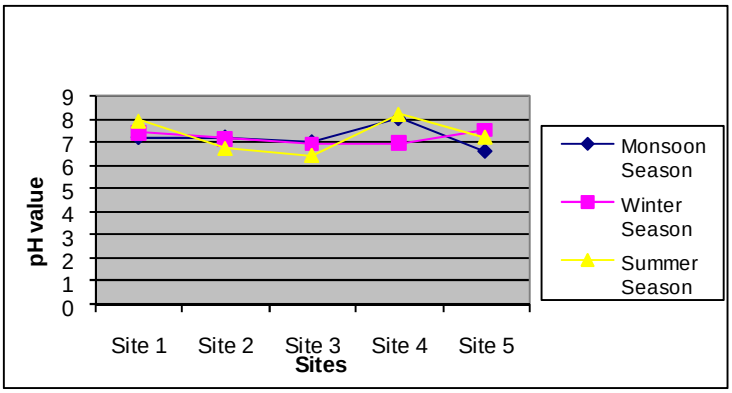

Figure 4: Seasonal and sitewise variation of pH

This fluctuation in seasonal pH might be due to addition of the bicarbonates from surrounding. According to the Shrestha (1983) and MPCA (2010), the water of the Rani Tal was suitable for the survival of all semiaquatic and aquatic animals. Since

Mugger Crocodile is semiaquatic animal. The water in Lake was suitable for survival of Mugger Crocodile.

3.1.3 Surface water temperature

Figure 5 clear that Monsoon season showed some what similarities with summer season, the average value obtained in monsoon season was 26.5^{o} C (Annex 10) with highest value observed at Site 1 and lowest at Site 4 of 26^{o} C. Other Sites like Site 2, 3 and 5 respectively had 26.6^{o} C of temperature (Annex 12). Mean surface winter temperature of Rani Tal in winter was 17.3^{0} C(Annex 10) with highest temperature at Site 2 of 18^{o} C followed by 17.4^{0} C, 17.5^{0} C and 17^{0} C at Site 1, 3 and 5 respectively. The lowest temperature of 16.5^{0} C was reported at Site 3 (Annex 11). Average summer surface temperature of Rani Tal was 28.50^{o}C (Annex 10) with highest temperature at Site 1 of 30^{o} C followed by Site 3 of 29.5^{0}C. Site 2, 4 and 5 had receptively 28^{0} C, 28^{0} C and 29^{0} C of surface temperature (Annex 13). The summer season temperature ranged from 28^{o}C-30^{o} C and winter temperature ranged from 10.5-18^{o} C in different sites. Summer showed sitewise fluctuation from to 26^{o} C to 27^{o} C (Figure 5, Annex 11, 12, and 13).

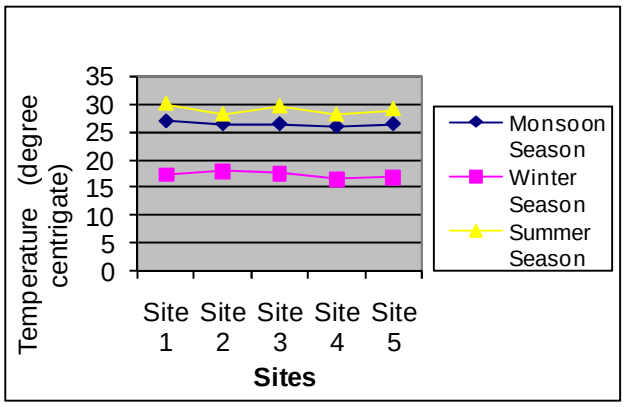

Figure 5: Seasonal and sitewise variation of temperature

This wide fluctuation of the the temperature in year might be due to the low depth of the Lake and high interaction with the atmospheric circulation. According to Boyd (1979), winter season has somewhat low temperature for survive for most fishes, hence might affect Mugger Crocodile.

3.1.4 Transparency

Transparency couldn't be measured in all season and all Sites due to high species coverage at surface and below water of floating and submerged species in monsoon

and winter season. However transparency measured at some sites varied from 0.7 to 0.8 meter in winter season (Figure 6, Annex 11).

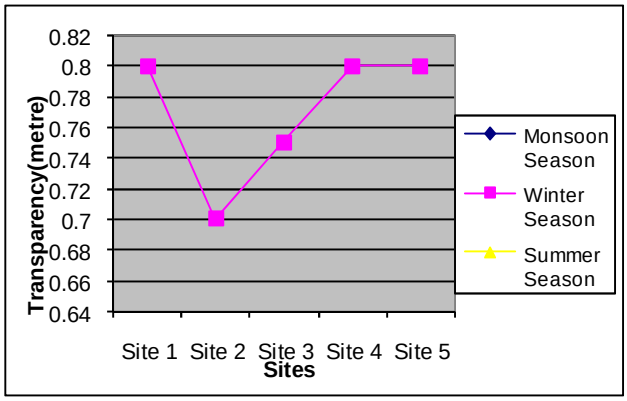

Figure 6: Transparency in Winter Season

3.1.5 Conductivity

Figure 7 shows that In Monsoon season, Conductivity had average value of 313.3 µS/cm (Annex 10). The highest value of 400 µS/cm was reported at Site 3. Sites 4 had least value of 223 µS/cm. Site 1, 2 and 5 had respectively 302.5µS/cm, 317 µS/cm and 324 µS/cm of Conductivity in monsoon (Annex 12). In winter season, the Conductivity showed average value of 165.8 µS/cm (Annex10) with highest value reported at Site 3 of 243 µS/cm and least at Site 4 of 117 µS/cm. Site 1, 2 and 5 were reported to be 171 µS/cm, 173 µS/cm and 125 µS/cm of conductivity value (Annex 11). The Summer Season had 152.80 µS/cm of highest value with lowest value in monsoon season of 143.6 µS/cm. Summer season showed average value of 199 µS/cm. In summer, the highest value was reported at Site 4 of 232 µS/cm and lowest value of 123 µS/cm at Site 1. Site 2, 3 and 5 respectively had 213 µS/cm, 214 µS/cm and 213 µS/cm of Conductivity respectively (Annex 13). Sitewise Conductivity ranged from 223 - 400 µS/cm in monsoon. Summer season showed range of 123 to 214 µS/cm and winter season showed sitewise variations of 123 to 232 µS/cm (Figure 7, Annex 10, 11, 12, and 13).

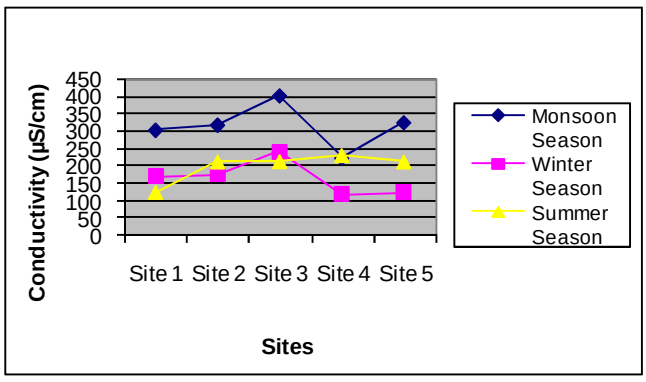

Figure 7: Seasonal and sitewise variation of conductivity

This high Conductivity reported in Rani Tal might be due to the addition of nutrient from surrounding due to flood water or the salt rich sediment. Compared with value reported by the WHO (1996), the water of Rani Tal was suitable in range what fresh water body need.

3.1.6 Dissolved Oxygen

According to Figure 8, Monsoon season shadowed great depletion in DO with mean DO of 3.58 mg/lt with highest value at Site 5 of 4.3 mg/lt and lowest at Site 4 of 3.95 mg/lt. Similarly, Site 1, Site 2 and Site 3 respectively had 3.42 mg/lt, 4.08 mg/lt and 3.10 mg/lt DO value (Annex12). Rani Tal was found to have average DO of 8.19 mg/lt during winter season (Annex 10) with highest value of DO at Site 2 and lowest value of 7.486 mg/lt DO at Site 4. Site 1, Site 3 and Site 5 respectively had 8.08 mg/lt, 8.468 mg/lt and 8.081 mg/lt in winter (Annex11). There took slight decline in the DO value in summer seasons having mean value of 5.25 mg/lt. Highest value of DO level of 6.3 mg/lt was observed at Site 2 with lowest level of DO value at 4.74 mg/lt at Site 4. Other sites like Site 1, Site 3, and Site 5 had 5.42 mg/lt, 4.98 mg/lt and 4.83 mg/lt of DO level respectively (Annex 13). Annual DO ranged from 2.95 to 4.35 mg/lt in monsoon season. In winter season, DO ranged from 7.48-8.860 mg/lt and 4.74 -6.3 mg/lt in summer season respectively (Figure 8, Annex 10, 11, 12, 13).

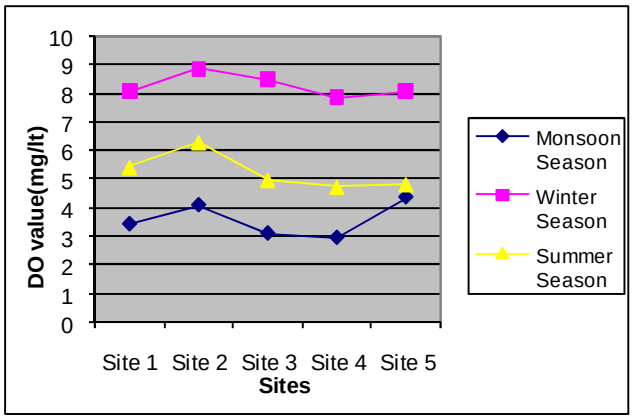

Figure 8: Seasonal and sitewise variation of DO

Heavy deposition and decomposition in monsoon season might have caused the decrease in the oxygen content in Lake water. According to EPA (2005) and Field Ecology lab (2000), in monsoon season and some sites in the winter season was not in supportive range for survival of many aquatic and semiaquatic animals. Acccording to Shrestha (1983), the water was not suitable for drinking of Mugger Crocodile due to less oxygen content. The water was lethal to aquatic animal according to the Field Ecology lab (2000) in monsoon season and some sites in the winter season

3.1.7 Chloride

The mean value of 34.42 mg/lt Chloride content in Monsoon season (Annex 10). It showed somewhat increase in Chloride content with highest value observed at Site 4 of 34.2 mg/lt followed by 3.08 at Site 1in monsoon. Site 5 showed the lowest Chloride content of 29.5 mg/lt. Site 2 and 3 respectively have 33.2 mg/lt and 30.8 mg/lt of Chloride content (Annex 12). Annual range of fluctuation shows 30.96 mg/lt in winter to 34.42 mg/lt in monsoon season. In winter season Chloride reported to be with mean value of 30.96 mg/lt with highest value at Site 4 and Site 5 as 32.66 mg/lt. Lowest value of the Chloride was reported at Site 2 of 29.82 mg/lt. Site 1 and Site 3 reported as 28.4 mg/lt and 31.24 mg/lt of Chloride content respectively (Annex 11). Summer season showed somewhat same values regarding winter season. Here in summer season Site 4 had highest value of 34.2 mg/lt followed by 33.2 mg/lt at Site 2. Site 1, 3 and 5 had respectively 29.4 mg/lt, 30.8 mg/lt and 29.5 mg/lt of Chloride content (Annex 13). Chloride ranged from 29.5-34.2 mg/lt sitewise in monsoon season. In summer season it ranged from 29.4 mg/lt to 34.2 mg/lt and 9.89 to 13.40 mg/lt in winter season (Figure 9, Annex 10, 11, 12, and 13).

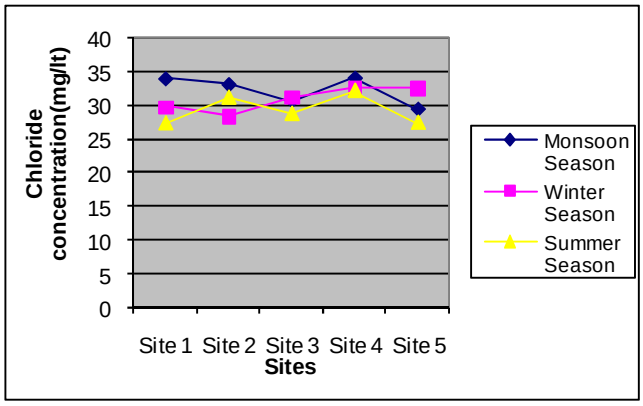

Figure 9: Seasonal and sitewise variation of Chloride concentration

This heavy fluctuation in Chloride concentration in the year might be due to the addition of chloride salts from the surrounding by monsoon water. According to the UN (1995) and MPCA (2010) Chloride concentration observed in the Rani Tal was suitable for most of the aquatic and semiaquatic animals. Hence the limit observed was suitable for drinking by Mugger Crocodile.

3.1.7 Hardness

Monsoon season had average value of Total Hardness of 100 mg/lt (Annex 10). The highest value of Total Hardness of the 135 mg/lt was observed at Site 3 and minimum of 80 mg/lt at Site 2. Site 1, 3 and 5 have respectively 80 mg/lt, 105 mg/lt and 90

mg/lt of the Total Hardness (Figure 12, Annex 12). The average value of the Magnesium Hardness observed at 51.0 mg/lt (Annex 10) with highest value observed at Site 3 of 89 mg/lt and lowest value observed of 24 mg/lt at Site 1. Other sites like Site 2, Site 4 and Site 5 respectively had 42 mg/lt, 45 mg/lt and 36 mg/lt of the Magnesium Hardness. Highest value of Calcium Hardness of 66 mg/lt was observed at Site 1 and lowest value of 38 mg/lt is observed at Site 2. Site 3, Site 4 and Site 5 respectively had 46 mg/lt, 40 mg/lt and 54 mg/lt (Figure 11, Annex 12). Winter season showed average value of the 10 mg/lt of the Total Hardness (Annex 10). The highest value of the Total Hardness observed at the Site 2 of 13.4 mg/lt and lowest value of 9.8 mg/lt at Site 2. Other Sites like Site 1, 4 and 5 respectively had 11 mg/lt, 9.89 mg/lt and 9.89 mg/lt of Total Hardness (Figure 12, Annex 11). Magnesium Hardness shows average value of the 5.32 mg/lt (Annex 10) with highest value observed at Site 2 of 7.2 mg /lt and lowest value of 4.4 mg/lt at Site 4. Other sites like 1, 3 and 5 had 4.6 mg/lt, 5.6 mg/lt and 5.6 mg/lt of Magnesium Hardness (Figure 11, Annex 11). Calcium Hardness was about 5.32 mg/lt and at Site 2 it has highest value of Hardness of 6.2 mg/lt and least of 4.9 mg/lt at Site 5. Other sites like Site 1, 3 and 5 have respectively 5.4 mg/lt, 5.2 mg/lt and 5.4 mg/lt of Calcium Hardness (Figure 10, Annex 11). Similarly, summer season had average Total Hardness of the 89.84 mg/lt (Annex 10) at highest value observed at Site 3 of 102 mg/lt and lowest value of 75.8 mg/lt at Site 2. Site 1, 4 and 5 had 80, 95 and 96 mg/lt of Total Hardness (Figure 12). Average value of the Magnesium Hardness observed is 27.10 mg/lt (Annex 10) with highest value observed at the Site 2 of 39.9 mg/lt and least of 20 mg/lt at Site 3. Other sites like Site 1, 4 and 5 have respectively 35 mg/lt, 32mg/lt and 30 mg/lt of Magnesium Hardness (Figure 11, Annex 13). Average value of Calcium Hardness observed is 58.398 mg/lt (Annex 10) with highest value observed at site 3 of 82 mg/lt and least value observed at Site 2 of 35.59 mg/lt. Site 1, 2 and 4 respectively had 45 mg/lt, 63 mg/lt and 66 mg/lt of Calcium Hardness (Figure 10, Annex 13).

Calcium Hardness ranged from 38 - 66 mg/lt in monsoon by sitewise, 35.9 - 82 mg/lt in summer and 4.9-6.2 in winter season respectively (Figure 10, Annex 11, 12 and 13). Magnesium hardness ranged from 24 mg/lt -89 mg/lt in monsoon 4.4 mg/lt -7.2 mg/lt in summer and 20 mg/lt to 39.9 mg/lt in winter (Figure 11, Annex 11, 12 and 13). Total hardness ranged from 80 mg/lt -1135 mg/lt in monsoon 75.8 mg/lt -102 mg/lt in summer and 9.8 mg/lt -13.4 mg/lt in winter season (Figure 12, Annex 11, 12 and 13).

Calcium Hardness

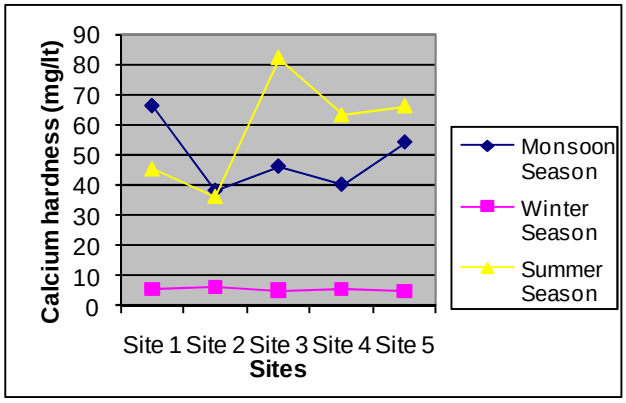

Figure 10: Seasonal and sitewise variation of Calcium hardness

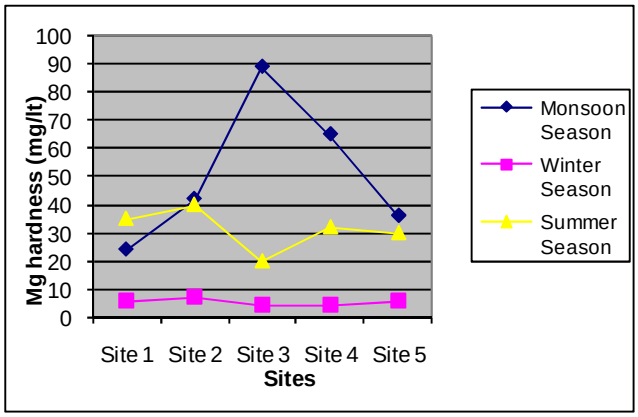

Figure 11: Seasonal and site wise variation of Magnesium hardness

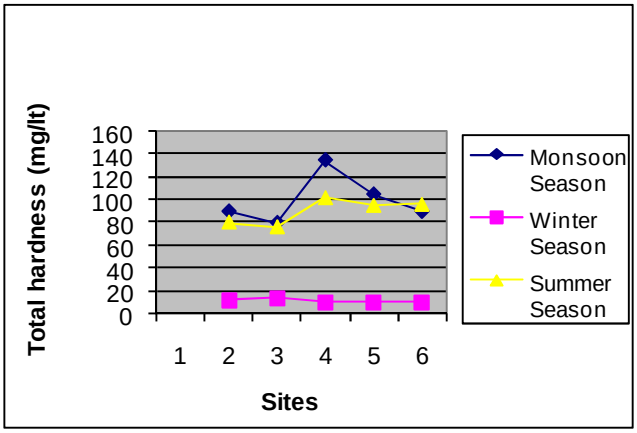

Figure 12: Seasonal and sitewise variation of Total Hardness

Somewhat high Hardness observed in the monsoon season might be from surrounding sediments or monsoon flooding. According to the limit given by the Swingle (1967) Total Hardness in winter season was not in limit to support many of aquatic and semi aquatic animals. Hence was considered not supporting for Mugger Crocodile

3.1.8 Total Alkalinity

Analysing Figure 13, Monsoon season showed somewhat same values at summer season. It showed mean value of 116.5 mg/lt (Annex 10) having highest value

observed at Site 1 of 112.7 mg/lt which was followed by 114 mg/lt at Site 2. Site 3, 4 and 5 have respectively 13 mg/lt, 115 mg/lt and 113 mg/lt of Total Alkalinity (Annex 12). Total Alkalinity in winter season had mean value of 139 mg/lt (Annex 10). The highest value of 150 mg/lt is reported at Site 4 and lowest value of 130 mg/lt at Site 3. Site 1, 3 and 5 had respectively 135 mg/lt, 140 mg/lt and 140 mg/lt (Annex 11). Summer season showed somewhat decline in Total Alkalinity with average value of 116 mg/lt (Annex 10). The highest value reported at Site 1 with 127 mg/lt and lowest value of Total Alkalinity at Site 4 is 105 mg/lt. Sites like 2, 3 and 5 respectively have 114 mg/lt, 105 mg/lt and 111 mg/lt of Total Alkalinity (Annex 13). Annual fluctuation of Total Alkalinity ranges from 116 mg/lt in summer to 139 mg/lt in winter season. Alkalinity ranged from 113 mg/lt to 127 mg/lt in monsoon season, 105-127 mg/lt in summer and 130-150 mg/lt in winter season (Figure 13, Annex 11, 12 and 13).

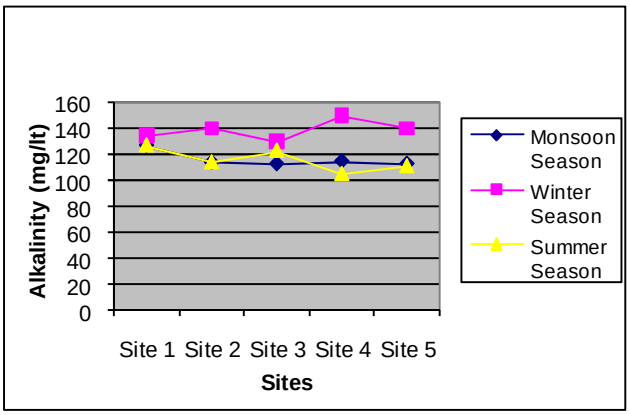

Figure 13: Seasonal and sitewise variation of alkalinity

High Alkalinity observed in winter season might be due to not consumption of the bicarbonate added from surrounding during monsoon season.

3.1.10 TDS, TSS and TS

Total Dissolved Solids

Winter season showed the mean total solids of 1167 mg/lt (Annex 10). Total Solid was reported at Site 3 of 1600 mg/lt, 1220 mg/lt in Site 4, 1200 mg/lt at Site 1 and 1015 mg/lt at Site 5. The minimum value of 800 mg/lt was observed at Site 2 (Figure 16, Annex 11). TDS showed highest value of 800 mg/lt at Site 1 and Site 3. Site 2, 4 and 5 showed 600 mg/lt, 420 mg/lt and 415 mg/lt of TDS (Figure 14, Annex 11). TSS showed highest value of the 800 mg/lt at Site 3 and Site 4 (Figure 15, Annex 11). Similarly Site 1, 2 and 5 had respectively had 400 mg/lt, 200 mg/lt and 600 mg/lt of TSS (Annex 11). Summer season showed somewhat less amount of the TDS. It

showed the average of the 443.4 mg/lt of TDS (Annex 10). The highest value of TDS about 502 mg/lt was observed in Site 4 followed by 435 mg/lt at Site 1. Site 2, 3 and Site 5 respectively had 413 mg/lt, 415 mg/lt and 402 mg/lt of TDS (Figure14, Annex 13). TSS of 237.6 mg/lt average was observed. Site 5 showed highest value of 293 mg/lt. The highest value of TSS could be seen in Site 4 about 207 mg/lt Site 1, Site 2 and Site 3 respectively had 215 mg/lt, 223 mg/lt and 250 mg/lt of TSS (Annex 13). Average 671 mg/lt of TS was observed (Annex 10) with Site 4 of 709 mg/lt followed by 695 mg/lt of the TS at Site 5 (Figure 16, Annex 13). Site 3, 2 and 1 showed 665 mg/lt, 636 mg/lt and 650 mg/lt of TSS respectively (Figure 15, Annex 13). Monsoon season showed the highest value of the TS observed about mean value of the 1328 mg/lt (Annex 10) with highest value observed at Site 3 of 1427 mg/lt which was followed by the 1423 mg/lt at Site 4. Site 2, Site 1 and Site 5 respectively had 1400 mg/lt, 1330 mg/lt and 1310 mg/lt of average value of TS (Figure 16, Annex 12). TDS showed average value of 625.60 mg/lt with highest value of TDS at Site 1 of 900 mg/lt which was followed by the 705 mg/lt at Site 2. Site 3, 4 and 5 had 543 mg/lt, 510 mg/lt and 510 mg/lt of TDS. TSS showed average range of the 690.40 mg/lt with highest value of the 914 mg/lt at Site 3 followed by the 913 mg/lt at Site 4. Site 1, Site 2 and Site 5 respectively had 500 mg/lt, 315 mg/lt and 810 mg/lt (Figure 15, Annex 12). Talking to annual context highest value of TDS, TS and TSS observed in monsoon season followed by winter season. TDS ranged from 500-900 mg/lt, 402-435 mg/lt and 415-800 mg/lt in monsoon, summer and winter season respectively. Similarly TSS ranged from 315 to 394 mg/lt in monsoon, 207-293 mg/lt in summer and 20-800 mg/lt in winter season respectively. TS ranged from 1310-1427 mg/lt, 636-709 mg/lt and 800-1600 mg /lt in monsoon, summer and winter season respectively (Figure 14, 15 and 16, Annex 11 12 and 13).

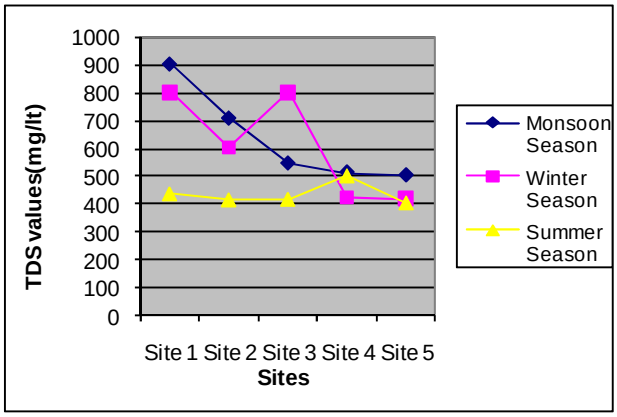

Figure 14: Seasonal and sitewise variation of Total Dissolved Solids

Total Suspended Solids

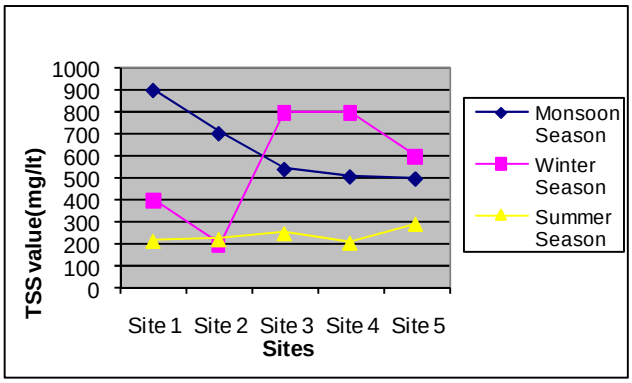

Figure 15: Seasonal and sitewise variation of Total Suspended solids

Total Solids

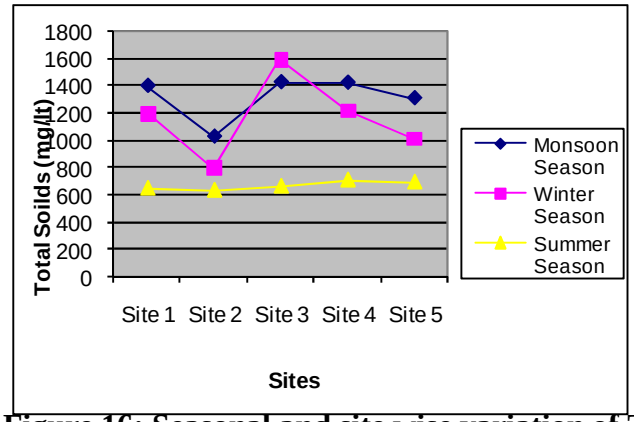

Figure 16: Seasonal and site wise variation of Total Solids

High load of the TDS, TSS and TS in year might be due to collection of sediments and organic load from surrounding. According to UN (1995) the water is not supportive for aquatic use by animals. But according to Shrestha (1983) the TDS, TSS and TS are supportive for the survival of Mugger Crocodile.

3.1.11 Nitrate

In Monsoon, Nitrate showed the average value of the 0.240 mg/lt (Annex 10) with highest value Nitrate content of the 0.425 mg/lt at Site 1 which was followed by 0.260 mg/lt at Site 2. Site 3 had lowest value of the 125 mg/lt of Nitrate. Site 4 and Site 5 respectively showed 0.195 mg/lt and 0.190 mg/lt of Nitrate content (Annex 12). Winter season showed average value of 0.480 mg/lt of Nitrate content (Annex10). The highest value of the Nitrogen content was found to be 0.631 mg/lt at Site 5. Site 3 had about 0.270 mg/lt of the Nitrate content. Site 1, 2 and 4 respectively had 0.554 mg/lt .0.456 mg/lt and 0.543 mg/lt of the Nitrate content (Annex 11). Summer season showed the highest value of 0.828 mg/lt average value of Nitrate content (Annex 10). The highest value of the Nitrate content was found at Site 1 about 0.982 mg/lt which was followed by 0.97 mg/lt at Site 4. Site 2 had least value of 0.55 mg/lt. Site 3 and 5

had respectively had 0.84 mg/lt and 0.77 mg/lt of the Nitrate content (Annex 13). Sitewise Nitrate in winter, summer and monsoon season respectively ranged from 0.125 to 0.425 mg/lt, 0.58-0.982 mg/lt, 0.270-0.631 mg/lt (Figure 17, Annex 11,12 and 13).

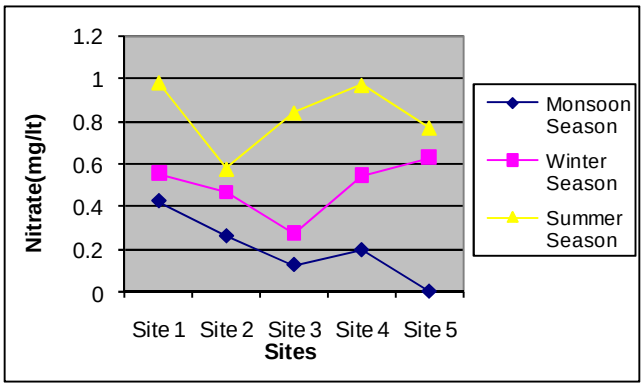

Figure 17: Seasonal and sitewise variation of Nitrate

According to limit given by UN (1995) Nitrate content in Rani Tal was supportive for survival of aquatic and semiaquatic animals. Hence was considered suitable for Mugger Crocodile.

3.1.12 Orthophosphate

In monsoon season, Average value of Orthophosphate was observed of 0.671 mg/lt (Annex 10) with highest value of 0.84 was observed at Site 3. Site 2 and Site 4 had almost same value of 0.732 mg/lt. Site 5 had least value of 0.472 mg/lt content of Phosphorous. Site 1 showed the lowest concentration of the 0.581mg/lt of the phosphate content (Annex 12).Winter season showed the average value of the 0.8 mg/lt of Orthophosphate content (Annex 10). The high value of the Phosphate was observed at Site 2 of 1.388 mg/lt and lowest at Site 1of 0.568 mg/lt. Site 3, 4 and 5 had respectively 0.71 mg/lt, 0.606 mg/lt and 0.732 mg/lt of Phosphate content (annex 11). Summer Season showed average value of 0.3104 mg/lt of the Orthophosphate (Annex 10) with highest value of at Site 3 of 0.375 mg/lt and least value observed at Site 5 of 0.245 mg/lt. Site 1, 2 and 4 had respectively 0.3 mg/lt, 0.342 mg/lt and 0.375 mg/lt of phosphate content respectively (Annex 13). In monsoon, Orthophosphate value ranged from 0.472-0.84 mg/lt, winter season ranged from 0.568 to 1.388 mg/lt and summer ranged from 0.245-0.375 mg/lt (Figure 18, Annex 11, 12, 13).

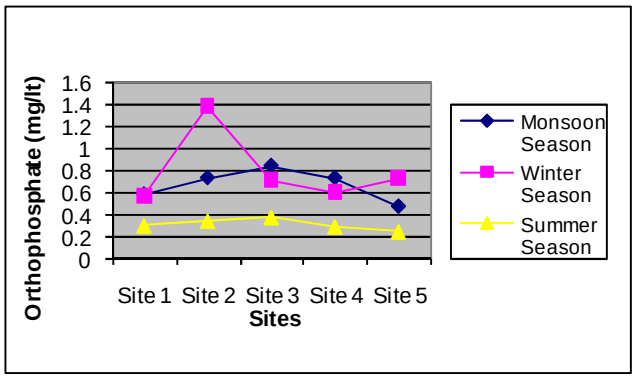

Figure 18: Seasonal and sitewise variation of Orthophosphate

Almost high amount of the Orthophosphate was observed in Rani Tal whole year might be due to the addition of Phosphate content from surrounding soil and flooding water. According to UN (1995) the Orthophosphate content was not suitable for most of semiaquatic and aquatic animals in winter and monsoon season. Hence it was not suitable for Crocodile to survive.

3.1.13 Potasium

The highest average value of the Potassium was obtained in the monsoon season about 1.27 mg/lt (Annex 10) with highest value obtained at Site 5 of 1.52 mg/lt and lowest value observed at Site 4 of 1.05 mg/lt. Site 1, 2 and 3 shows 1.24, 1.23 and 1.3 mg/lt of Potassium content (Annex 12).The average value of the Potassium reported in summer was 0.050 mg/lt (Annex 10) with highest value present in the Site 3 of 0.062 mg/lt and lowest value reported at Site 4 of 0.40 mg/lt. Other sites like Site 1, 2 and 4 had respectively 0.042 mg/lt 0.052 mg/lt and 0.060 mg/lt of Potassium (Annex13). In winter season, average value of the Potassium reported was 1 mg/lt (Annex 10) with highest value observed at Site 1, 2 and 5 of 0.66 mg/lt and remaning site contained of 0.65 mg/lt. Highest value of Potassium was obtained in monsoon season. In summer season, it ranged from 0.040-0.062 mg/lt, 1.05-1.52 mg/lt in monsoon season and 0.65 to 0.66 mg/lt in winter (Figure 19, Annex 11, 12 and 13).

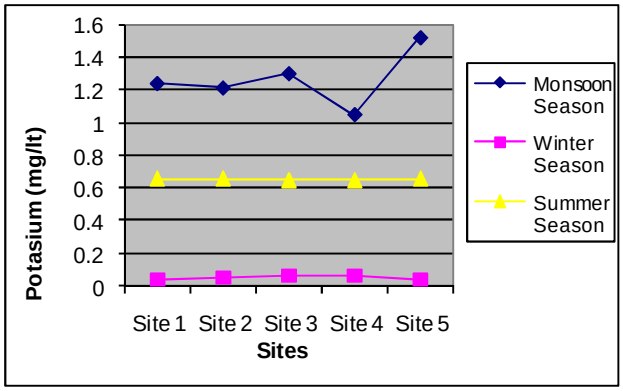

Figure 19: Seasonal and sitewise variation of Potasium

High Potassium observed in monsoon might be due to addition of potassium salt and other Potassium bases from brunt ash.

3.1.14 Carbondioxide

CO_2 content of average 8.48 mg/lt was observed as mean value in monsoon season (Annex 10). Site 2 had 12.8 mg/lt of the CO_2 followed by 9.6 mg/lt at Site 1. The lowest value of 5.2 mg/lt was observed at Site 4. Site 3 and Site 5 recorded 7.2 and 7.6 mg/l of CO_2 (Annex 12). Winter season showed average value of 33 mg/lt (Annex 10). The highest value of 41.8 mg/lt of CO_2 were observed at Site 1 and least value observed at Site 2 of 35.2 mg/lt. Site 3, 4 and Site 5 were reported to be 37.5 mg/lt of the CO_2 content (Annex 11). In summer season average value of the CO_2 recorded was12.80 mg/lt (Annex 10). The highest value of it was observed at Site 1 of 16.3 mg/lt in summer season and 10.2 mg/lt of CO_2 at Site 4. Site 2, 3 and 5 had respectively 12.4 mg/lt, 13.2 mg/lt and 11.9 mg/lt of CO_2 content (Annex 13). Comparatively, average highest value of 33 mg/lt was found in winter and lowest in summer of 8.48 mg/lt. CO_2 showed sitewise range of 5.2-12.8 mg/lt in monsoon season, 10.2-16.3 mg/lt in summer season and highest fluctuation in range 35.2-41.8 mg/lt in winter season (Figure 20, Annex 11, 12, 13).

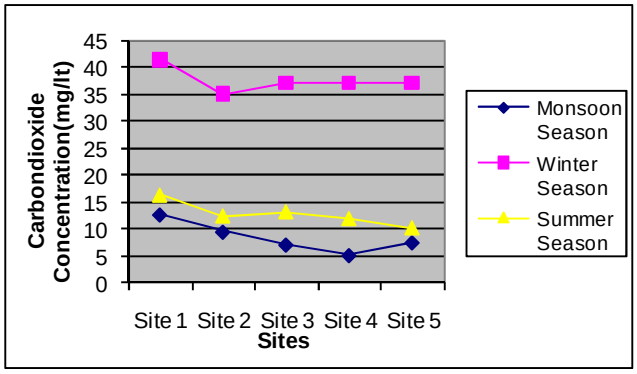

Figure 20: Seasonal and Sitewise variation of CO_2

High decomposition rate might be cause of decline of CO_2 content in summer and monsoon season, while as somewhat high value observed in winter might be due to low use by the surface and submerged plant. According to APHA *et al.* (1998) the CO_2 content was not suitable for fish, other aquatic animal, and subaquatic animal and terrestrial wildlife propogation. Hence, was not considered suitable for of Crocodile.

3.1.15 Sodium

Mean value of 51.20 mg/lt of Sodium was reported in monsoon season (Annex 10). In Site 1 it showed the 56 mg/lt of highest value. Site 3 showed the least value of

Sodium content of 48 mg/l. Site 2, 4 and Site 5 respectively showed 53 mg/lt, 50 mg/lt and 49 mg/lt (Annex12). Sodium in winter season showed average content of 16.74 mg/lt (Annex 10) with highest value of 18 mg/lt at Site 1 and lowest value at Site 2 of 13.5 mg/lt. Site 3, 4 and 5 respectively had 16.9 mg/lt, 17.4 mg/lt and 17.9 mg/lt of Sodium content (Annex 11). Similarly, summer season showed average 18.9 mg/lt of Sodium content (Annex 10). Highest Sodium content was reported at Site 2 of 20 mg/lt in summer season. Site 3 showed the lowest value about 15 mg/lt. Site 1, 4 and 5 showed values respectively of 19 mg/lt, 18.5 mg/lt and 19 mg/lt of Sodium content in summer season (Annex 13). Among all season highest mean value of Sodium of 51.20 mg/lt was reported in monsoon season and lowest at winter season of 16.74 mg/lt. Annual seasonal range of the Sodium ranged from 49 to 56 mg/lt in monsoon season, 13.5-18 mg/lt in winter and 18-19 in summer season (Figure 21, Annex 11, 12, 13).

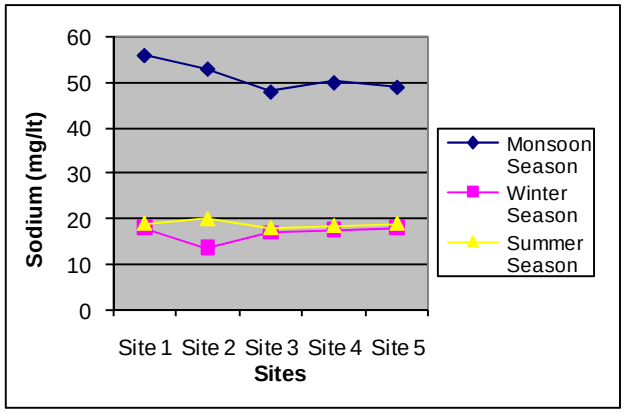

Figure 21: Seasonal and sitewise vartiation of Sodium

High concentration of Sodium content during monsoon season might be due to the addition of Sodium salt from surrounding soil.

3.1.16 Total Nitrogen

Total Nitrogen of 6.66 mg/lt was reported in monsoon season with highest value observed at Site 5 of 7.34 mg/lt and lowest value of the 6.32 mg/lt at Site 3. Site 1, 2 and Site 4 respectively had 6.53 mg/lt, 6.34 mg/lt and 6.88 mg/lt in monsoon season (Annex 12). Winter season showed slight lower value of the Total Nitrogen with mean amount of the 4.184 mg/lt (Annex 10) and highest value observed at Site 1 of 5.3 mg/lt. Similarly, Site 3 had value 3.7 of minimum. Site 2, 4 and 5 respectively had 4.7, 4.02 and 3.7 mg/lt of Total Nitrogen in winter season (Annex 11). Summer season showed highest mean value of 10.72 mg/lt of Total Nitrogen (Annex 10) with highest value observed at Site 5 of 11.9 mg/lt. The lowest value of Total Nitrogen was

9.57 mg/lt at Site 1. Site 2, 3 and Site 4 respectively had 10.52, 11.3 and 10.7 mg/lt of Total Nitrogen content (Annex 13). Seasonal value ranged sitewise as 6.32 to 6.88 mg/lt in monsoon season, 3.2 to 5.3 mg/lt in winter season and 9.57 to 11.3 mg/lt in summer season (Figure 22, Annex 11, 12, 13).

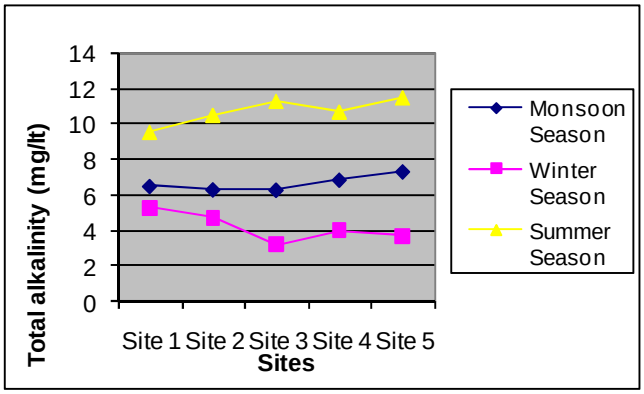

Figure 22: Seasonal and sitewise variation of Total Nitrogen

High amount of Total Nitrogen in summer might be due to heavy decomposition of macrophytes. Total Nitrogen content helps to add the Nitrate content in water.

3.1.17 Productivity

Gross Primary productivity (GPP)

Mean value of 0.18 gm.C.m^2/hr was reported in monsoon season (Annex 10) with highest value observed at Site 1 of 0.21 gm.C.m^2/hr and lowest value of 0.15 gm.C.m^2/hr. Site 2, 3 and Site 5 had 0.19 gm.C.m^2/hr, 0.20 gm.C.m^2/hr and 0.17 gm.C.m^2/hr of primary productivity in monsoon season (Annex 12). Similarily, 0.26 gm.C.m^2/hr of mean value GPP in summer season was reported (Annex 10) with highest value of productivity at Site 2 of 0.28 gm.C.m^2/hr and lowest value was reported at Site 5 of 0.23 gm.C.m^2/hr. Site 1, 3 and 4 had respectively 0.27 gm.C.m^2/hr, 0.25 gm.C.m^2/hr and 0.26 gm.C.m^2/hr of GPP in summer season (Annex13). Winter season showed mean gross productivity of 0.33 gm.C.m^2/hr (Annex11) with highest value observed at Site 5 of 0.34 gm.C.m^2/hr and lowest value observed at Site 1 of 0.31 gm.C.m^2/hr. Site 2 showed 0.32 gm.C.m^2/hr. and Site 3 and Site 4 had same value of the 0.33 gm.C.m^2/hr. GPP ranged from 0.15 to 0.21 gm.C.m^2/hr in monsoon season, 0.31 to 0.34 gm.C.m^2/hr in winter season and 0.23 to 0.28 gm.C.m^2/hr in summer season (Figure 23, Annex 11, 12 and 13).

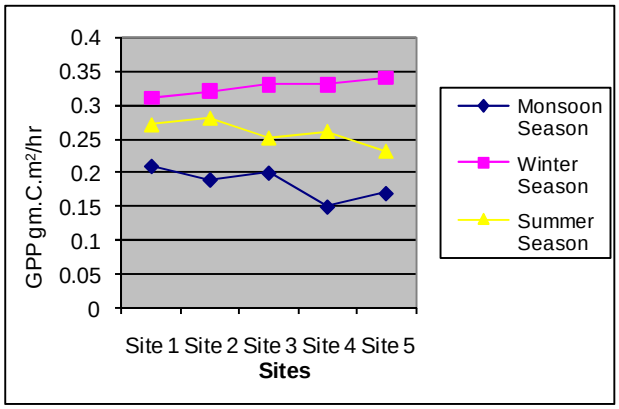

Figure 23: Seasonal and sitewise variation of GPP

Net Primary Productivity (NPP)

In context of NPP, monsoon season had average value of 0.49 gm.C.m^2/hr (Annex 10). In monsoon season, the highest value of 0.53 gm.C.m^2/hr reported at Site 3. The lowest value of NPP reported at Site 1 of 0.46 gm.C.m^2/hr. The Site 2, 4 and 5 respectively have 0.52 gm.C.m^2/hr, 0.49 gm.C.m^2/hr and 0.47 gm.C.m^2/hr of NPP in monsoon season (Annex 12). The average value of the 0.65 gm.C.m^2/hr reported in summer season (Annex 10). The highest value reported at Site 1 of 0.76 gm.C.m^2/hr and lowest value observed at Site 3 of 0.58 gm.C.m^2/hr. Site 2, 4 and 5 have respectively 0.59 gm.C.m^2/hr, 0.63 gm.C.m^2/hr and 0.68 gm.C.m^2/hr in summer (Annex 13). The average value of NPP observed in winter season was 0.94 gm.C.m^2/hr (Annex 10). The highest value reported at Site 5 of 0.94 gm.C.m^2/hr and 0.83 of lowest value reported at Site 1. Site 2, 3 and 4 respectively reported 0.90, 0.87 and 0.93 gm.C.m^2/hr of NPP (Annex 11). Highest NPP was reported in winter season of 0.89 gm.C.m^2/hr. NPP ranged from 0.47 to 0.53 gm.C.m^2/hr in monsoon season 0.83 to 0.94 gm.C.m^2/hr in winter season and 0.58 to 0.76 gm.C.m^2/hr in summer season (Figure 24, Annex 11, 12 and 13).

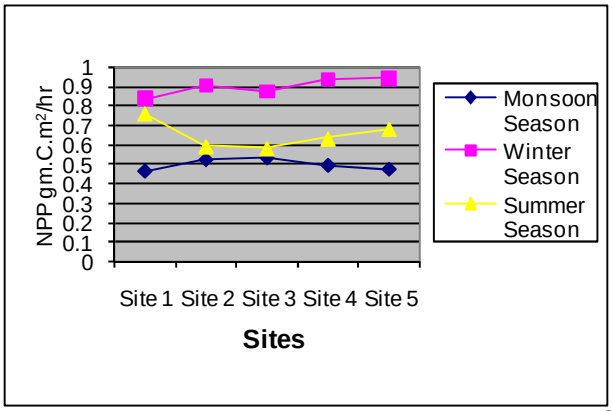

Figure 24: Seasonal and sitewise variation of NPP

Rani Tal showed good productivity all round year.

3.1.18 BOD (5 days Biological Oxygen Demand)

BOD reflected average value of 13.20 mg/lt at summer season (Annex 10) with highest value observed at Site 4 of 15.5 mg/lt and minimum value of 10.12 mg/lt at Site 1. Site 2, 3 and 4 had respectively 12.6 mg/lt, 13.5 mg/lt, and 14.2 mg/lt of BOD in summer (Annex 13). In winter season average BOD value reported to be 17.08 mg/lt (Annex 10) with highest value observed at Site 2 and least value about 16.4 observed at Site 1. Site 3, 4 and 5 respectively have 17.3, 16.72 and 16.73 mg/lt of BOD value (Annex 11). Similarily in Monsoon season average value of BOD observed was 33.78 mg/lt (Annex 10) with highest value of 35.61 at Site 3 and least value of 32.4 at Site 4. Site 1, 2 and 5 had 33.33 mg/lt, 34 mg/lt and 33.6 mg/lt of BOD (Annex 12). BOD ranged from 10.12-15.5 mg/lt in summer season and in monsoon season, it ranged from 33.3-35.6 mg/lt. In winter season, it ranged from16.4 to 18.7 mg/lt (Figure 25, Annex 11, 12 and 13).

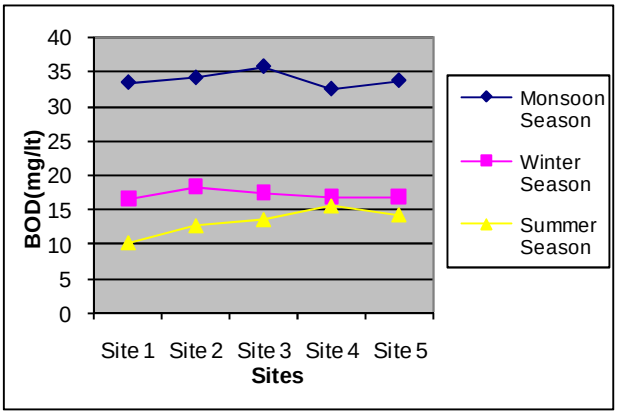

Figure 25: Seasonal and sitewise variation of BOD in Rani Tal

High BOD observed might be due to addition of the organic nutrients from surrounding. The Lake water was observed with somewhat higher value prescribed by UN (1995) for aquatic and semiaquatic use for drinking. Hence, the BOD can be considered to be not supportive for the Mugger Crocodile.

3.1.19 Ammonia

Monsoon season showed average value of Ammonia about 0.08 mg/lt (Annex 10) with highest value observed at Site 1 of 0.095 mg/lt and least value observed at Site 3 and Site 5 of 0.73 mg/lt of Ammonia. Site 2 and Site 4 showed 0.085 and 0.074 mg/lt of Ammonia content (annex 12). Similarly, winter season showed average value of 0.02 mg/lt of Ammonia content (Annex 10) with highest value observed at Site 4 of 0.026 mg/lt and lowest value at Site 2 of 0.002 mg/lt. Other sites like Site 1, 3 and 5 respectively had 0.021 mg/lt, 0.025 mg/lt and 0.005 mg/lt of Ammonia (Annex 11). In

summer season, average value of Ammonia observed was 0.060 mg/lt (Annex 10) with highest value observed at Site 2 of 0.071 mg/lt and lowest value of 0.061 at Site 4 and Site 5. Site 1 and 3 respectively had 0.062 and 0.065 mg/lt of Ammonia content (Annex13). Ammonia ranged sitewise as 0.073-0.095 mg/lt, 0.002 -0.026 mg/lt, and 0.061 - 0.071 mg/lt in monsoon, summer and winter season respectively (Figure 26, Annex 11, 12 and 13).

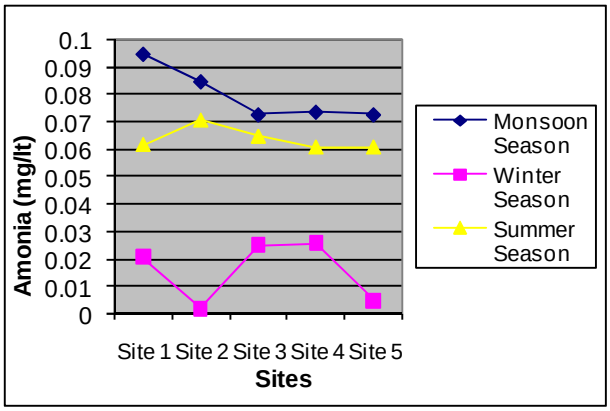

Figure 26: Seasonal and sitewise variation of Amonia

High level of Ammonia reported at some sites might be due to the addition of nutrient from surrounding and heavy decomposition of OM. According to MPCA (2010, the Lake water was not suitable for survival/drinking of many aquatic and semiaquatic animals in winter and monsoon season. Hence, Ammonia has been supposed not to be suitable for Mugger Crocodile.

3.1.20 Total Phosphorous

Total Phosphorous ranged from 0.99 to 1.30 mg/lt in monsoon season with highest value observed at Site 1 of 1.30 mg/lt and lowest value at Site 3 of 0.99 mg/lt. Other sites like 2, 4 and 5 have 1.02 mg/lt, 1.2 mg/lt and 1.12 mg/lt of total Phosphorous (Annex 12). In winter season, highest value of the Total Phosphorous observed at Site 2 of 1.82 mg/lt and lowest of 0.93 mg/lt at Site 3. Site 1, 4 and 5 reported to have 1.02 mg/lt, 0.762 mg/lt and 0.99 mg/lt of Phosphate content (Annex 11). Summer season showed highest value of the 1.325 mg/lt at Site 4 with least value observed at Site 3 of 0.495 mg/lt. Site 1, 2 and 5 respectively had 0.952 mg/lt, 0.662 mg/lt and 0.765 mg/lt of the Total Phosphorous content (Annex 13). Summer season ranged from 0.495 to 1.325 mg/lt (Figure 27, Annex 11, 12 and 13).

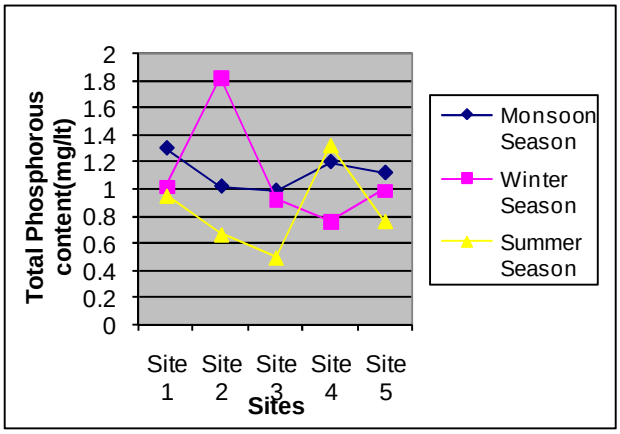

Figure 27: Seasonal and sitewise variation of Total Phosphorous in Rani Tal

Amount of the total Phosphorous might be from surrounding soil or heavy accumulation from flooding water. High amount of total Phosphorous contributes the Orthophosphate content.

3.1.21 Arsenic

Arsenic content was found to be nil in all samples of all station. Absence of Arsenic might be due to absence of Arsenic present rock.

3.2 Seasonal Soil and Sediment analys

3.2.1 Bottom soil analysis

3.2.1.1 Soil pH

pH varied from acidic to alkaline in year almost with little change. pH in monsoon season ranged from 6.7 to 7.3, 6.5 to7.4 in winter and 6.8 to 7.2 in summer season (Figure 28, Annex 6, 7 and 8).

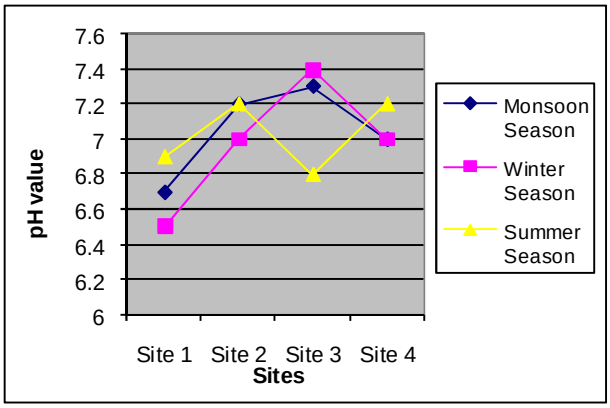

Figure 28: Seasonal and sitewise variation of pH in Lake Bottom

The soil pH was almost neutral according to Pradhan (1996).

3.2.1.2 Soil Conductivity

The conductivity ranged from 402 to 513 µS/cm in summer season. In winter it varied from 342 to 453 µS/cm and im summer season it ranged from 243 to 569 µS/cm sitewise (Figure 29, Annex 6, 7 and 8).

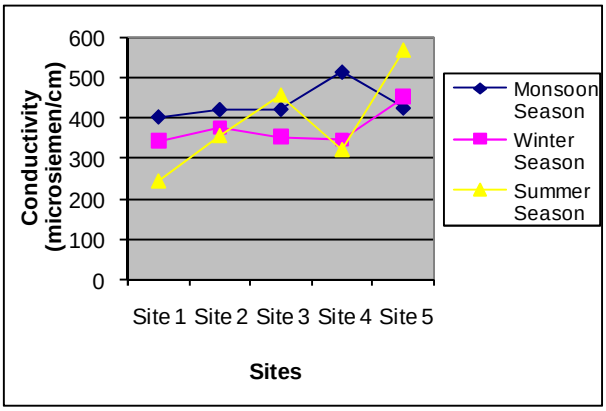

Figure 29: Seasonal and sitewise variation of bottom Soil conductivity

This high conductivity might be due to high amount of salt present in soil.

3.2.1.3 Soil Texture analysis

Soil texture of Lake bottom found to be ranging from clay loam, sandy caly to clay soil.

3.2.1.4 Soil organic Mater for Bottom soil

OM was found to be very high in Lake bottom. It was found to be ranging from 9.2 % to 11.2 % in Monsoon season. The winter season ranged from 8.0 % to 9.5 % and summer season ranged from the 9.2 to 13.9 % (Figure 30, Annex 6, 7 and 8).

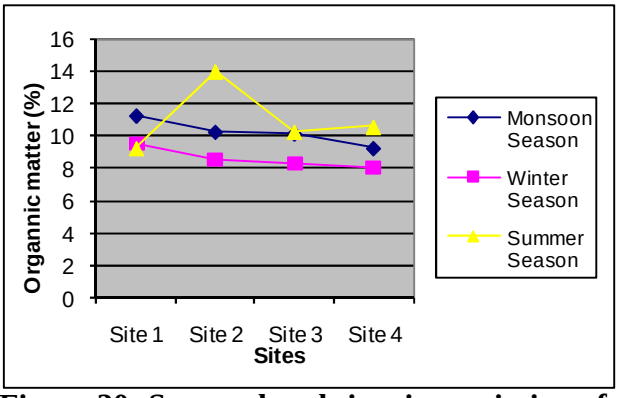

Figure 30: Seasonal and sitewise variation of OM in Lake Bottom

According to the Pradhan (1996) it was very high amount of the OM. It might be due to heavy loading from surrounding soil as surrounding soil also had found to be high amount of OM, contributing lake to enrich organic mater.

3.2.1.5 Total Nitrogen

The Total Nitrogen was found to be ranging from 1.45 % to 5.33 % in Monsoon season. In winter season it ranged from 0.442 % to 4.350 % in different sites. In summer season it ranged from 0.47 % to 4.4 % of Total Nitrogen (Figure 31, Annex 6, 7 and 8).

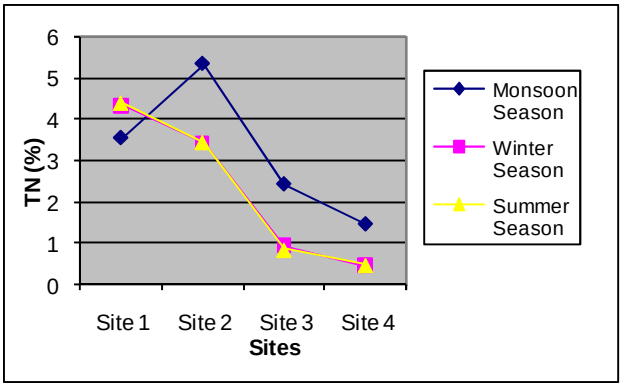

Figure 31: Seasonal and Site wise variation of Total Nitrogen in bottom soil

According to Pradhan (1996), the Total Nitrogen content was also very high in Rani Tal. It also might be from heavy decomposition of macrophytes and surrounding addition. This content was also contributing lake water to enrich nitrogen content.

3.2.1.5 Potassium

Potassium was reported to be ranging from 402 to 416 Kg/ha in monsoon season. In winter season, it ranged from 321 to 361 kg/ha. In summer season, Potassium ranged from 244 to 314 kg/ha (Figure 32, Annex 6, 7 and 8).

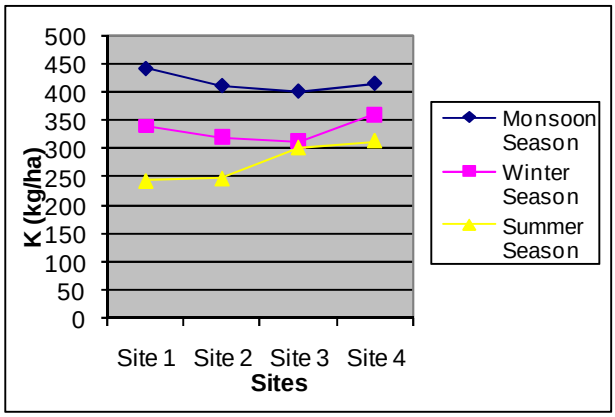

Figure 32: Seasonal and sitewise variation of Potasium content in Lake Bottom

According to range given by Pradhan (1996), this concentration of Potassium was high for soil. This high amount of Potassium might be from inflow of ashes and other soil OM. It was not contributing lake water so much.

3.2.1.6 Orthophosphate

High available Phosphate was reported in Lake bottom during all seasons which ranged from 417 to 533 kg/ha in monsoon season. In winter , somewhat decrease in Phosphorous content ranging from 310 to 389 kg/ha was found. Summer showed 315 -325 kg/ha range of the Orthophosphate content (Figure 33, Annex 6, 7 and 8).

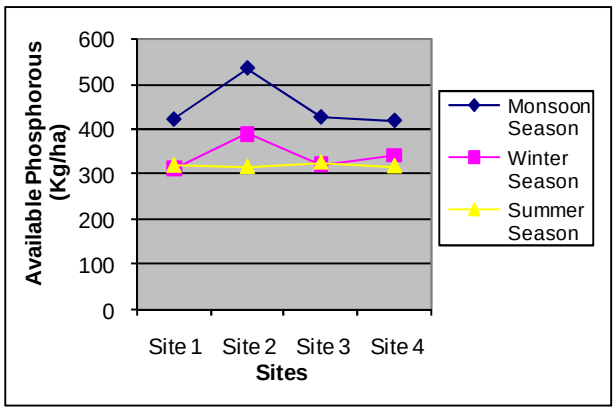

Figure 33: Seasonal available Phosphorous content with sitewise

The content of Phosphorous obtained was very high amount according to Pradhan (1996). This heavy Phosphorous content might be due to the high decomposition of macrophytes, collection flooding awter from surrounding as sorounding soil was rich in Phosphorous. This available phosphorous was considered contributing in lake water eutophication.

3.2.1.7 Soil calcium and Magnesium

Soil Calcium was found to be ranging from 9.24 to 11.3 % in monsoon season, 5.45 to 8.25 % and 9.24 to 14 % in winter and summer season respectively (Figure 34). Soil Magnesium ranged from 3.29 to 6.03 % in monsoon season. Similarly in winter and summer season it was found to be ranging from 3.29 to 6.39 % and 3.4 to 5.34 % respectively (Figure 35, Annex 6, 7 and 8).

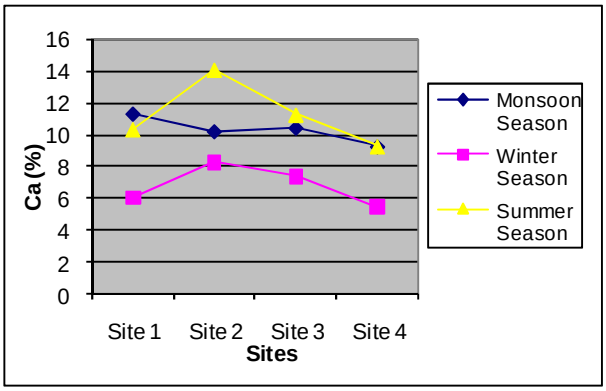

Figure 34: Seasonal and site wise variation of Calcium in bottom soil

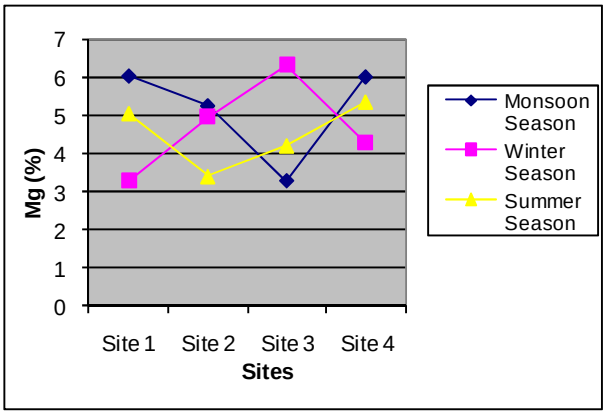

Figure 35: Seasonal and site wise variation of Magnesium in bottom soil

3.3. Soil analysis of site vegetation

Site soil had the average pH of 5.2 and 4.9 respectively in site 1 and site 2 which was highly acidic soil. The moisture content comprised of 33.4 % and 32 % in Site 1 and Site 2. OM content was found medium of 3.2 % and about 4.2 % in Site 1 and Site 2. Avaialable Phosphate showed high range from 150 to 160 Kg/ha in Site 1 and Site 2.Total Nitrogen found to be ranging from 0.32 % to 0.30 % at Site 1 and 2 respectively. Potassium ranged from 232 to 240 Kg/ha from Site 2 to Site 1 respectively. Similarly, Calcium and Magnesium content found to be ranging from 9.04 - 9.12 % from Site 2 to Site 1 and 5.08 to 6.12 % from Site 1 to Site 2 respectively. The textural classes showed the Sandy clays to Clay loam soil. The WHC of soil was found to be 39 and 37% in Site 1 and Site 2. The conductivity found to be ranging from 225-245 µS/cm (Annex 9).

3.4 Vegetation analysis

The floating species on the Rani Tal had covered almost whole water body except the initiation of winter season. Floating vegetation include *Nymphea nouchali, Nelumbo nucifera, Trapa quadrispinosa* species together with alien species like *Pistia straoites.* In counter to the free floating plants estimation, high coverage was found due to *Trapa quadrispinosa, Nelumbo nucifera, Nymphea nouchali, and Pistia straiotes.* The species *Nymphea nouchali, Pistia straiotes* and *Trapa quadrispinosa* found to have 100% frequency with lowest frequency of *Hydrilla vercillata. Pistia straoites* found to have highest density and dominance followed by *Nymphea nouchali.* Here *Nymphea nouchali, Pistia straiotes and Trapa quadrispinosa* had 100% frequency which was followed by *Nelumbo nucifera, Ludwigia adscendens* and *Lemna minor*

with 75% frequency. *Pistia straiotes* had highest density 117.8 pl/m^2 followed by *Lemna minor* of 95 pl/m^2 and followed by the *Potmogaton nodusus* and *Wolfia globusa* of 93.9 pl/m^2 and 85.4 pl/m^2. Floating community has the diversity index of 0.86 which is high diversity index shows the plant community is highly diverse (Annex 14).

In analysis of Marsh vegetation, the highly encroaching native species *Phragmites karka* found to have encroached about 80% of the reed beds. The coverage of the floating plants was almost 90% in the monsoon but whole coverage found decayed and dried during winter and summer season. In Site 1, the total density of the plant was found to be 96.67 pl/m^2 or (966,700 pl/ha) with high density of the *Phragmites karka* with 50 pl/m^2 (500,000 pl/ha) followed by *Sachrum spontanium* with19.5 pl/m^2 or (195,000 pl/ha), *Imperata arundinacia* with 9.5 pl/m^2 or (95,000 pl/ha), *Erianthus ravaennae* with 6.62 pl/m^2 or (66,200 pl/ha) and *Arundo donax* of 8.41 or (841,000 pl/ha). Similarly *Phragmites karka, Arundo donax, Imperata arundinacia, Erianthus ravaennae, Sachrum spontanium* etc contain 100% frequency or most occurring plants with *Aphuda mutica* with least frequency of 25%. Highest relative frequency 11.11 % was found among *Phragmites karka, Sachrum spontanium, Imperata arundinacia, Erianthus ravennae* and *Arundo donax.* About relative density, *Phragmites karka* had found highest relative density of 30.41% followed by *Sacchrum spontanium* of 19.5% with least relative density of *Polygonum barbatum* of 0.26%. *Phragmites karka, Sachrum spontanium, Imperata arundinacea, Erianthus ravennae* and *Arundo donax* had 100% frequency hence could be called dominant species according to Raunkieirs frequency class percentage (Annex 4). The least relative frequency was found of 5.56 % of *Themeda arundinacia, Polygonbum barnbatum* and *Perscaria hydropiper* hence could be called as rare species. Highest coverage was found of *Phragmites karka* and least coverage of *Aphuda mutica. Phragmites karka, Sachhrum spontanium, Imperata cyllindrica* and *Erianthus ravannae* had higher relative coverage percentage than other species (Annex17). It was also found that Phragmites *karka* in the Lake margin had also cover round the almost whole Lake body. It was found to be disturbing for the much of wildlife for watering due to only small open patches to enter the Lake where grassland animals should have highly alert of their predators (Focus group discussion, 2009).

In plot 2, *Phragmites karka* also had the highest density of the 42 (420,000 pl/ha) and minimum of the 0.07 pl/m^2 (7000 pl/ha) of the *Acorus calamus*. In total density of 69.28 pl/m^2 the invasive species *Alternanthera Philoxeroids* contains density of 4.03 pl/m^2 or (40,300 pl/ha) *Phragmites karka* also had highest relative density among all vegetation. In the marsh *Phragmites karka, Erianthus ravennae, Sachhrum spontanium,* these three contained of 100% frequency and 17.39% of relative frequency respectively in plot 2. Others like *Cyperus rotundus, Acorus calamus, Altenenthera philexoroids and Diplazium esculatum* had least frequency of 50% and Relative frequency of 8.69 respectively. *Phragmites Karka* had highest relative dominance of 60.62% with least 0.10 for *Acorus calamus*. Similarly in total coverage of the 38.4 %, this had more than half percent coverage in plot 2. Phragmites karka had highest relative coverage of 37.58% with least relative coverage of 0.85% of *Acolus calamus*. The highly encroaching species like *Phragmites karka* which has given platform to invading *Sachhraum spontanium, Erianthus ravinnae* and others. It was reported that these three species were always together because of the *Phragmites karka* make areas easier for invasion by *Sachhraum spontanium, Erianthus ravainnae* (Annex 17).

During the study/field visit in Rani Tal, many other alien species were recorded from SWR were *Eichornia carrissepes, Hyptis svaveolens, Aregemone mexicana, Mimosa pudica, Casia tora, Ageratum conyzoids, and Ipomea carnea ssp.fistulosa.* Other alien species recorded are *Euphorbia hirta, Steleria media, Oxalis corniculata, Ludwigia sps, Eclipta prostrate and Brachia mutica.*

Talking to the climbers, the *Bahunia Vahlii* and *Dioscorea bulbifera* were found to be dominating but the *Spatholobus parviflorus* was found to be less dominating. In plot 1 *Bahaunia vahlii* was found to have density of 111.11 pl/ha and *Dioscorea bulbifera* with 77.77 pl/ha and 55.55 Pl/ha of *Spatholobus parvifolus. Bahaunnia vahlii* was found to be high domnance of 0.25 which was followed by *Dioscorea bulbifera* and *Spatholobus parvifolus* of 0.10 and 0.05 of dominance. All total diversity indexes in Site 1 found to be 0.46. In plot 2 same plants were sighted with same range of parameters. The *Dioscera bulbifera* with 166.66 pl/ha here found to have highest density and *Bahunia vahlli* with 155 pl/ha. Similarily *Spathlobous parvifolous* found to have 122.22 pl/ha of density. *Dioscorea bulbifera* here was found to have high dominance of 0.14 which was followed by *Bahunai valli* of 0.12. The *Spatholobous*

parvifolous was least dominating. The climber comminity here showed diversity index of 0.47. In plot 3 the climbers community was found to be nill (Annex 18).

In analysis of the trees, Site 1 was found to be dominated with the *Shorea robusta* with dominance value of 0.0680 together with *Syzygium cumini* (0.0117) Kukurdiano (0.00755), *Dalbergia* sissoo (0.0042), *Mallotas phillipensis* (0.00425), *Sclerchera oleosa* (0.*00425*. The lowest dominance was observed of *Aporusa octandra* and *Astoria scholaras. Shorea robusta* had found to be high density of 133.33 pl/ha which was followed by *Syzgium cumini* (55.55 pl/ha), Kukurdiano (44.44 pl/ha) and other had medium density. *Aporusa octandra* had least density and *Alstoria scchloras* of respectively 11.11 pl/ha reported. Plant coommunity at Site 1 found to have the highest diversity index of approx 1 which indicate highly diverse community with total density of 511.06 pl/ha (Annex 16).

Similarily, Site 2 was found to be dominated by the species *Shorea robusta, Adina cardifolia, Listia monopetala,* respectively with dominant index of 0.0306, 0.01 and 0.00562 with least dominance found of rare species *Bombax cieba of 0.000625. Toona ciliata, Terminalia belleceria, Carea arborea* of same dominance value as *Bombax cieba. Shorea robusta* had found to be highest density of 77.77 pl/ha followed by the *Adina cardifolia* 44.44 pl/ha and least density found of 11.11 pl/ha of speceis *Bombax cieba. Toona ciliata, Terminalia belleceria, Carea arborea* were of same dominance value as *Bombax cieba.* Aprroximate species diversity index of 1 was reported at this site denotes that the community is highly diversed. Here, Total density of plant was found 444.44 pl/ha. Thus community was highly dense (Annex 16).

Site 3 was found to be dominated highly with *Shorea robusta* of 0.0108 dominance index which was followed by *Syzygium cumini* with domince index of 0.2725. This procedure was followed by the *Albizia Nepalennsis* and *Aspera octandra* of dominance indexes same as 0.00906. The species like *Apporusa octandra, Engchardia spicata, Phoenix aculis* had least dominnce and density of 0.00056 and 11.11 Pl/ha. The species like *Shorea robusta, Syzygium cumini, Albizia Nepalnensis* and *Aspera octandra* respectively have 88.88 pl/ha, 77.77 pl/ha and 44.44 pl/ha, 44.44 pl/ha density respectively. The total density of community was found to be 471.24

pl/ha at Site 3 which is also high density.Total plant density in Rani Tal ranged from 444.44 to 571.46 pl/ha which was very high density (Annex16).

Highly diverse and densed community of tree and climbers at Rani Tal area might be contributing water storage in soil pore , erosion control as well as nutrient addition by litter input to lake. Surface and floating vegetation found to be encroaching the lake area and helping in eutrophication by litter addition and decaying of palnt part.

3.5. Litter composition and Biomass analysis

High biomass of litter content was found in Rani Tal. Both sites repectively had average water content of 51.64 % and 49.37 % of water content and biomass of 826.24 gm/m^2 and 789 gm/m^2. This is high amount of biomass. High amount of soorounding biomass also contribute the addition of organic materials in the Lake body. High litter content in Rani Tal might helping in adition of organic content in Rani Tal by with taking it to Lake by with monsoon water (Annex 5).

3.6 Population status of Mugger Crocodile in Rani Tal

Questionnaire survey reveals following Primary information on wetlands of Shuklaphata and the Mugger Crocodile surviving there.

Table 4: .Mugger finding areas in SWR with average number

Areas	Average number in range
Bahuni Nala (Jhulghat and Kaptan Ghat mostly)	6-8
Dangakunda	4-6
Patharia Nala	4-6
Mahakali River	8-10
Patharia Pond	2-4
Chudhara River or Chaudhara Nala (Verginia Tal)	6-8
Hatti Kund	2-4
Bhauraya Nala	2-4
Padsera Gaudi Nala	4-6
Hagnia Nala/RaniTal	2-4
Andaya Pataiya	4-8
Shurya Phata Khalla	4-8

Chaupheri Khalla	4-6
Radhapur Khalla	3-8
Majhgaun Nala	2-4
Kalikitch Tal	1-2
Sahili Nala	1-2
Estimated total numbers of the Mugger Crocodile In SWRs	59-98

Hence the total number of the Mugger Crocodiles in SWR was reported to be 59 to 98 in range through questionnaire survey (Annex 20).

3.7 Result of Observation

3.7.1 Population census of Mugger Crocodile: Continuous survey of about 15 days in Rani Tal reported 4 Marsh Muggers (Annex 15).

3.7.2 Threats to Rani Tal

a) Invasion by native and alien species

Rani Tal was found to be encroached highly by the *Phragmites karka* and the presence of alien species like *Alternanthera philoxeroids* and with surface covering of *Pistia sraiotes*. The native species like *Phragmites karka* found to have covered the almost whole periphery of Lake. Large number of the *Pistia straiotes* and other floating leaved plants might add Organic content and deplete the oxygen level (Field observation, 2009). Invasion by *Phragmites* had decreased area of Rani Tal (Personal communication: Chand Chandra Bahadur, 2009, Field observation, 2009)).

b) High eutrophic condition/Poor water quality

Water quality assessment reveals the hyper eutrophic condition of the Lake on basis of the amount of the phosphorus and Nitrate content comparing with value given by Forsberg and Ryding (1980).

c) Dam impacts

Due to closed Dam, the flooding water with organic debris filled in the Rani Tal which had given the basement by addition of sediment to grow of the Narkat (*Phragmites Karka*). Addition of the OM content rich in Phosphorous and Nitrogen were helping the growth of *Phragmites karka.* Sedimentation and siltation found to

have decreased area of Rani Tal and this rate was agrevated by dam (Field survey, 2009). From personal communication it was repoeted that Seasonal flooding from Chaudhara river and sorrounding water also had caused siltation problem (Personal communication: Chand Chandra Bahadur, 2009).

3.8 Status of Rani Tal and Mugger Crocodile

From questionnaire survey, it was reported that highest Mugger Crocodile finding area was slow flowing pools of Mahakali River where 8-10 Mugger Crocodile were reported to occur. Almost 18 wetlands were found to be main region to occurrence of Mugger Crocodiles in SWR. The Rani Tal was found to have estimated number of 2-4 population of Mugger Crocodile. In aspect of Rani Tal, number of the Mugger Crocodiles found were depleted number than previous observedby previous dweller and frequent visitors. The dam site and inflow site of Lake together with laden trees and logs was found to be good habitat for Mugger Crocodile due to winter easier for basking and easier to search food. Respondents, the previous dweller of Shuklaphata and frequent visitors to the Rani Tal from last 50 year claimed Rani Tal's area and depth was decreasing than previous (Personal communication: Thakur Bholeman, 2009). It has been decreased by the 6 ft than previous due to the silting by flooding and invasion by Narkot (*Phragmites karka)* and other grasses. Questionnaire survey (Annex-16) revealed that about 10-50 years ago their occurred approximately 10-20 Mugger Crocodiles frequently. Personal communication with one of the frequent visitors of Rani Tal the Bholeman Thakur, claimed that Rani Tal reported more than 15 Mugger Crocodile at previous more than 20 years.Respondent also believed that Crocodile population in Rani Tal had decreased than previous(Figure 36). Similarily 10-15 years had gone for the invasion of the alien species like *Pistia, Alternanthera etc* (Personal communication: Thakur Bholeman, 2009). But together with Rani Tal other Lakes of the Shuklaphata like Sulgudi Tal, Kalikitch Tal, Tara Tal, Hatia Kund and Sikari Tal also have been suffering from invasion of the plant species (Personal communication:Bam Karna Bahadur, 2009). Questionnaire survey (Annex 20) also revealed that there gone about 10-25 years of *Phragmites karka* invasion. *Phragmites karka* was found to be developed here hugely from about 2027 BS (Personal communication: Thakur Bholeman, 2009). Among all Lakes present inside SWR, widely degraded was found to be Rani Tal. Eastern grassland site at connection of Rani Tal was found to be main region for basking preference by Mugger Crocodile

previously which was now invaded totally by the *Phragmites karka* and Mugger Crocodiles now have to be basking on Damsites and some open patches of inflow site.

Frequently 2 or 3 case there found the leaving of Mugger Crocodile to SWR. The event of injury by the public during past 10 years were about 8-10 events. About 2 events were from the Barmhdev area and mostly from Dhodhara, Raikbar Bichhuwa, Rauteli Bichuwa (Source: SWR record, 2009). Usually in the monsoon season, due to filling of the water inside Shuklaphata, Parents' Muggers carry their hatchlings and go to safe places usually higher region of reserve or outside the reserve but if they come to public affair they become injured (Personal communication: Mishra Nilambar, 2008). Talking to Mugger Crocodile in Rani Tal there found no event of the hunting and poaching of the Mugger Crocodile.

In questionarrie survey (Annex 20), 70% of the respondent said that the Mugger crocodile in Rani Tal had depleted in number than previous. The 20 % said that the status has not declined and 10% are not known to status (Figure 36).

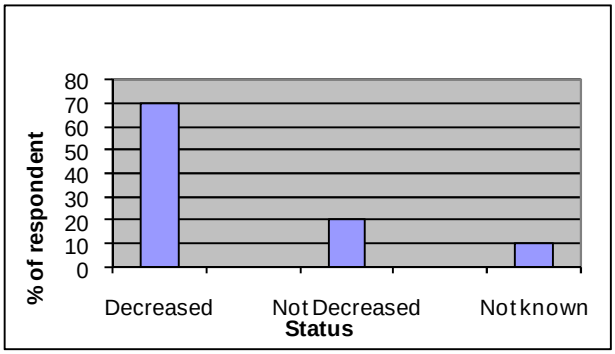

Figure 36: Population status of Mugger Crocodile at Rani Tal

Rani Tal was in safe security but found some illegal activity performed.There found egg collection activity of Mugger for medicinal purpose and diet, which was especially by Tharu community from the Raikwar bichuwa, Rauteli bichuwa and Beldadi area from Chaudhara River, Syali Nadi and etc (Figure 37, Personal communication: Chaudhary Lalu, 2009). It might hamper Mugger dwelling in Rani Tal area because Chaudhara River, Syali Nadi and etc regions lie nearby Rani Tal.

As illegal approach and poisionining on the Rani Tal was made by the Local Tharus. Tharu people on asking did not represent for them in going Rani Tal. But they point alternatively he or she goes for fishing purpose illegally to Rani Tal (Personal communication: Chaudhary Lalu, 2009). From respondent or the previous dweller of Shuklaphata there was reported that people frequently move to the Rani Tal area

illegally to collect Singda, Khar etc. 20 % of people have seen/heard the illegal fishing at Rani Tal. 5 % of the people believed that people frequently move to collect eggs of crocodile from Chaudhara river area. Other 20 % believed that mostly Tharu people go at Rani Tal area for Khar collection and Singda collection. Remaining 55% percentage of the publics has not heard about illegal activities (Figure 37).

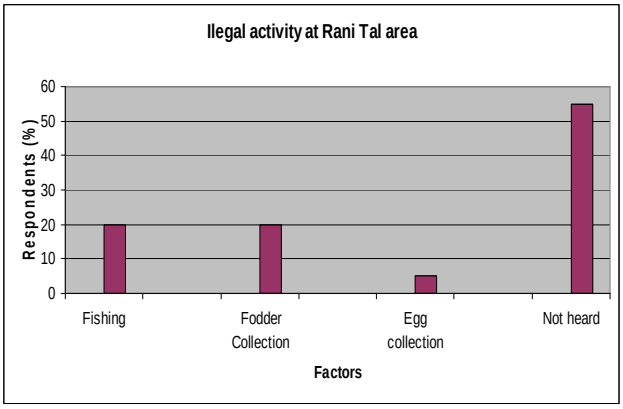

Figure 37: Illegal activity at Rani Tal

Most of respondents believed that for sustainable management of Lake *Phragmites* and other encroaching species, Alien plant and native species should be removed time to time; Dam outflow should be made with proper recharging. 100% of the Respondent's, the previous dweller of Rani Tal sites, ethnic community believed that cause behind the decrease in crocodile population at Rani Tal were No proper basking place by *Phragmites* invasion in lake area, Poor water quality, Low feeding for crocodile or not food sufficiency, and impact by Dam for free movement of hatchling.

3.9 Management options performed at Rani Tal

Reserve office usually perform the removing of plants from the Rani Tal using the Local Tharus by not paying but allowing them to collect the edible plants e.g. *Trapa* and other usable *Phragmites.* But the programmes were found not so effective (Personal communication: Upadhyaya Gopal Prashad, 2008). About past 10 year ago, Lake tended to be dry due to high addition of the silt and sands, then DNPWC built there dam at outflow side which was again damaged by the flood and the social worker Petter repaired it again to recover Lake water level in the Lake. But last time it's water level decreasing day by day. Interview reveals that boring was tried to recharge the differing Lake water in the SWR but it could not effective in Rani Tal due to ejection of too much sand during boring in The Rani Tal. As Lake was inaccessible approach to publics hence was found difficult to manage by the using the local people. To recover the water level in Rani Tal, reserve office in cooperation with

Mahakali Irrigation Project was trying to build canal from Chaudhara River to Rani Tal (Personal communication: Upadhyaya Gopal Prashad, 2008). One of the respondents Mr. Bhole Man Thakur made argument that due to not leaving the outflow holes from bottom of the Dam/embankment large amount of siltation took place during the flooding which made nutrient addition from the surrounding of Lake and tends to huge growth of the floras and degradation of Lake quality.

Many of respondent believed that the basking places should be managed and other habitat management in Rani Tal should be for the proper wellbeing of crocodile. Questionnaire survey revealed that earthen embankment has caused significant imact on the impact on the Lake by deteriotating the water quality.

There seen the difference in the number of the Mugger Crocodile before the earthen embankment construction or after earthen embankment construction. About more than eight Mugger Crocodiles were reported to occur before earthen embankment construction which is being reduced to 4 now. *Phragmites karka* and other grasses including invasive species have found to be increased after earthen embankment construction.

3.10 Threats to Mugger Crocodile at Rani Tal

Sedimentation and siltation processes help to decrease the Tal area as well as growth and survival of water fauna and flora. Similarly high nutrient status of Lake also helps to grow of the increased flora as lead to eutrophication and lead to the Lake deterioration. The water quality if not in permissible limit, it directly degrades the Lake hence effecting flora and fauna or disturbs the food web structure. As water contents is highly eutrophic with seasonal deficiency of oxygen might Kill the Fishes and other Lake organism which are food of the Mugger Crocodile. Crocodile is one of the major Carnivores in ecosystem if the quality of the Lake are enhanced it will directly harm the Lake depend Crocodile by declining in number of food materials for Carnivores. Narkot and earthen embankment have disturbed the Crocodile for freely moving (Focus group discussion, 2009). As high Narkot growth had not let the sandy soil bank to exist, this was desired habitat for the Mugger Crocodile. There is no a suitable sand bank for basking and nesting. Basking priority reed beds or islands are complete covered with reed beds.

CHAPTER 4

DISCUSSION

An ecosystem is a community of organisms' plants, animals, fungi and bacterias interacting with one another and with the environment in which they live. The physicochemical parameters of water are very important for the composition, abundance and distribution of living organisms in the aquatic ecosystem because the interaction of physicochemical parameters create either favorable or unfavorable circumstances for the particular biotic element. Abundance, diversity and distribution of animals are related to various physicochemical biotic factors (Dutta and Malhotra, 1986). Water quality is one of the most overlooked aspects of pond management - until it affects fish production. Several variables influence water quality for fish including water temperature, phytoplankton, photosynthesis, pH, CO_2, alkalinity and hardness. Hence, Threats on Mugger Crocodiles and Rani Tal were traced on the basis of field observation, result of data obtained from water quality, vegetation analysis, questionnaire survey and all related aspects in this study. Additionally, water quality can be affected through the interaction of these factors (Stevens, 2009) so almost all factors like bottom soil, site soil, vegetation, litter content was well studied. From analysis, the trophic classification given by the Forsberg and Ryding (1980) and OECD (1982) revealed the hypereutrophic condition of the Rani Tal on the basis of the phosphorous content and Total Nitrogen content (Annex 1) and seasonally most other parameters are also in out of limit. It might cause several impacts on the biotic life surviving there even to Mugger Crocodile directely or reducing food content of Mugger Crocodile. Since any aspect of change in Lake body cause change in living status of top carnivorous by reducing producers and consumers. Mugger Crocodile is top carnivores of system, hence threat factors are determined directly and indirectly. Because any aspect of harm in producer and consumer level of the Lake ecosystem might harm the Crocodile population.

Pollution level in Rani Tal may be studied from its color reflect which ranged from light green, green color to yellow green. The color in water may remit from presence of natural metallic ions (iron and manganese), humus and peat materials, plankton, weeds and industrial wastes (APHA, AWWA, WEC, 1998). Due to the presence of the high amount of the green and blue green algae usually the presence of the phytoplankton exhibits the green color (Agrawal, 1999)**.** Light green color of water observed in monsoon is indicator of the pollution or enrichment of the organic

nutrients. BACH (1980) gave the chemical index of water in which green color reflects the moderate pollution and light green indicate the critical pollution. Rani Tal ranged from light green to the yellow green color from monsoon to summer. In monsoon season, Rani Tal supported the critical pollution which might be due to the addition of nutrients from surroundings which was less in summer and winter season. Somewhat green color reflected might be due to the growth of green algae. Moderate pollution shows the oxygen content above 6 mg/lt and Ammonia in 0.3-0.4 mg/lt. In the condition of critical pollution oxygen content is 4 or even less with BOD 5-10 mg/lt according to BACH (1980). With same color matching for critical pollution Rani Tal showed higher BOD range then this limit.

The hydrogen ion concentration of water body is one of the most important local factors known to influence fish community composition (Appelberg *et al.* 1992). The pH is measure of alkalinity and acidity measures or hydrogen ion concentration in water. pH and CO_2 content shows the negative correlation because photosynthesis activity removes the CO_2 which results in the precipitation of $CaCO_3$ by planktons. pH content is determined by the amount of organic and inorganic content. The increase in pH value indicates the presence of the phenolphthalein alkalinity pH (8.0) and decrease in the pH shows the absence of the phenolphthalein alkalinity (pH 6 to 7). The hydrogen ion concentration of the water body is on of the most important local factors known to influence community composition (Appelberg *et al*. 1993).

High range of pH fluctuation in Rani Tal occurred in monsoon. It might be due to the addition of bicarbonate from surrounding environment. The availability of the Carbon dioxide, bicarbonate, and carbonate depends upon the pH of water. In acidic water free CO2 predominates but it rapidly declines above the neutrality and pH between 7-9, bicarbonate and carbonate source. pH ranged from 6.4-8.2 in summer in Rani Tal. If pH declines below 6.5, few eggs hatch and the aquatic insect's level drop (UNESCO-IUCN, 2005). A pH ranging from 6.5 to 9 is best for the majority of the organism (Wurts and Durbow, 1992). Monsoon pH fluctuates at different sites toward alkalinity, might be addition of the bicarbonate salt from surrounding environment. Fluctuation of pH is due to the removal of carbon dioxide from water body by process of photosynthesis occurring in submerged aquatic plants (Schutte and Elsmorth, 1954). Rani Tal showed pH not so less to hamper aquatic organism. It was productive range of pH in Rani Tal. Fresh water with pH range of the 6.0 to 9.0 noted to be

productive and thus recommend for fish culture (Adenji, 1986; Anonymous, 1973). Swingle (1967) reported <5 and >11 have been described as toxic and vulnerable to the aquatic faunas. Natural water usually reveals pH value between 5 to 8.5 pH values as is shown by Rani Tal. Fish have an average blood pH of 7.4, so pond water with a pH close to this is optimum. An acceptable range would be 6.5 to 9.0. Fish can become stressed in water with a pH ranging from 4.0 to 6.5 and 9.0 to 11.0 values. Fish growth is limited in water pH less than 6.5 and reproduction ceases and fry can die at pH less than 5.0. Death is almost certain at a pH of less than 4.0 or greater than 11.0 (Stevens, 2009). Yadav, (1986) made study on effect of the pH in *Chauna punctuis* found death of fish when kept up to 3.7 in 6 hour exposure. pH and above up to 4 found change in Kydney system, hypertrophy in cells etc and above 9 and 10 drastic changes in physiology occur with kidney and hypertrophying of epithelial cells found degradation of the mucous cell, kidney damage, degeneration of mucous cell and in pH 11, ultimate death within 7 days exposure. In these all aspect, Rani Tal had suitable pH. Pond water pH fluctuates throughout the day due to photosynthesis and respiration by plants and vertebrates. Different researchers have different view on pH criteria. The hydrogen ion concentration of water below 5 and above 11 has been described as toxic and unsuitable for various groups of aquatic fauna by Bastola, (1999). UN, (1995) and Nepal water quality Guideline, GoN, (2009) reported 6.5 to 8.5 pH is recommendable for the common fresh water use and for livestock use. Out side the range 6-9 is health risk for fishes. Above and below of this range is harmful to many plants and animals. Nepal water quality Guideline, GoN, (2009) also reported for common aquatic species pH value should not fluctuate by 5%. Rani Tal followed this point. Here in Rani Tal, pH ranged to support the sustaining of the aquatic life almost. Pokharel and Sang Hu, (2008) reported same fact that pH of the Rani Tal was suitable for the aquatic animals.

Shrestha (1983) reported crystal clear and neutral water for well survival of crocodile. The water was found almost nearer to neutral can be considered as good for the survival of Crocodile. MPCA (2010) reported 6.0-9.0 range of pH for well survival of aquatic and semi aquatic animal. Since Mugger Crocodile is semi aquatic animal, according to given standard, Rani Tal showed the suitable range for survive this species.

Surface temperature showed average higher temperature in summer and lower temperature in winter is due to the interaction with atmospheric circulation. The high surface temperature during summer and monsoon might be due to low depth of Rani Tal. Due to low depth water heated quickly. Fluctuation in temperature in different sites might be due to some sites were shady and some to open sunshine areas. Summer season shows somewhat rise in temperature. Physical, biological and chemical processes in the aquatic environment are affected by the temperature. The rise in the temperature leads the speeding up of the chemical reactions in the water decreases the solubility of the oxygen in the water while increasing the Oxygen demand of the fish. Higher temperature increases the solubility of the many chemical compounds. The increase in the temperature was followed by the P^H and conductivity (Bhatt *et al*., 1999). The water temperature effects physical chemical and biological environment of Lake directly or indirectly. The dynamic of Oxygen distribution in Lakes are governed by balance between inputs of the atmosphere, photosynthesis and loses due to chemical and biotic oxidants (Wetzel, 1983). The rise in temperature speed up the chemical reactions reduces the solubility of gases and amplifies the taste and orders (Trivedi and Goels, 1986). Temperature variations are part of the natural climatic regimes. Natural bodies of the water may exhibit it seasonal and diurnal variation, as well as vertical stratification takes in Lake which is closely related with the changes in the atmospheric temperature (Kundanagar *et al.* 1996). High temperature is observed in summer season in Rani Tal. The high temperature usually occurs when it is high organic load and hot season. High temperature of surface water was observed in summer and monsoon season in the Rani Tal. Higher temperature increases solubility of gases. Increase in the temperature is followed by increase in pH and conductivity (Bhatt *et al.* 1999). Water temperature is one of the important factors in aquatic environment as it affects the organism as well as it affects chemical and physical characteristics of water (Delince, 1992; Abdo, 2005). The Oxygen retaining capacity of the water diminishes and biological oxygen demand increased with rising up of temperature (Holden and Armstrong, 1980). Temperature in range 20 degree to 32 degree in the water is ideal for the majority of fresh water fishes (Boyd, 1979). In winter season Rani Tal show value lower then this ideal temperature to survive fishes, hence, might hamper the fish's activity. When temperature goes far above or below the tolerance range of given taxons e.g. Fish, insect, Zooplankton, Phytoplankton and its availability to survive may be reduced (Hoegh-Guldberg, 1999). Water temperature influences the onset of fish spawn, aquatic vegetation growth and the

BOD in ponds. As water temperature increases, it holds less oxygen. Additionally, plants and animals use more oxygen due to increased respiration rates. These factors commonly result in less available oxygen for fish during the summer and fall months (Stevens, 2009). Nepal water quality Guideline, GoN, (2009) reported temperature of 4-18 ^{0}C is suitable for cold water, 6-32 for intermediate species and 24-30 for warm water fishes. Rani Tal support temperature for fish survival.

The transparency in water is also essentially a function of reflection of light from its surface and is therefore influenced by absorption characteristic of both water and of its dissolved and particulate matter (Wetzel 1983). Low winter transparency measured at some sites at Rani Tal might be due to high species coverage at surface water of floating and submerged species winter season and high TDS and TSS content. High species coverage at surface and submerged and high turbidity affect in measuring water transparency. Water transparency is important for photosynthesis. Low water transparency reflects low photosynthesis activity, as a result of which DO declines and organism may be stressed. Transparency is inversely related to the turbidity which is caused by the planktons and suspended solids in water column (Boyd, 1979). Inorganic particulates may have detrimental effect in the aquatic organisms, suspended particulate in the water provides vast amount of the surface area for the growth of the bacteria and fungi and could increase the potential for diseases in water system (Cairns, 1967). These diseases might affect the survival of hatchlings and young of different organism. Transparency showed high degree of the correlation with of Chloride content conductivity is measure of concentration of mineral constituents present in water and gives an idea about the dissolved solids in water (Khopkar, 2004).

The productivity of substance or solution depends upon no. and kind of ion presents, their relative charge and freedoms of ion to conduct as conductor. High value of the conductivity might be due to decrease in water level in Lake. The low value of conductivity in winter season might be due to consumption of the electrolytes and ions by aquatic plants. Monsoon season showed somewhat higher conductivity might be due to the inflow of soluble salt from surroundings. Conductivity of most freshwater ranges from 10-1000 µs /cm. Rani Tal supports this range. But many exceeds 10000 µS/cm especially in polluted water those nearly have large quantities of runoff (WHO, 1996). According to USEPA Inland fresh water indicates that stream

supporting good mixed fisheries have range between 150 and 500 µs /cm. Fluctuation from this can harm the fish population and other aquatic bodies. Conductivity outside this range could indicate that water is not suitable for water contain species of fish or macro invertebrates. In some sites in monsoon season, Rani Tal supports lower conductivity than this range may be harmful to many aquatic and sub aquatic organisms.

Do is also main factor for animal or plants in aquatic life. If not in suitable percentage, it might cause stress in animals and plants. DO shows high degree of the positive correlation with total alkalinity and chloride and significant negative correlation with the Nitrogen (Thapa, 2007). Increased range of DO in winter at Rani Tal is observed might be due to decrease in water and atmospheric temperatures. Summer showed somewhat decreased concentration might be due to high temperature of atmosphere. Wetzel, (2001) reported solubility of Oxygen in pure water in relation to temperature in equilibrium with air at standard temperature and pressure standard with water vapors. Usually solubility of the oxygen in water decrease with increase in temperature (Master, 2004). High temperature and salinity caused the Oxygen to be relatively low (Barden, 2001). As water warm holding capacity of Oxygen decreases and the DO released to the atmosphere (Agrawal, 1999). But in monsoon the Oxygen content found in stress may be due to high decomposition rate and addition of nutrient from surroundings. The decrease in the DO in Rani Tal might be due to high rate of the decomposition of OM and macrophyte community. Rai reported same concern in the Begnas Lake and Rupa Lake of the Kaski district of Nepal (Rai, 1999). A low concentration of the DO in the aquatic water body indices the organic pollution of the water quality (Verma and Agrawal, 1988). The Oxygen saturation concentration also depends upon temperature and salinity (Weiss, 1970). In contrast of the temperate and the polar Lakes the tropical Lake does not exhibit the marked seasonal fluctuation. And thus it, do not exhibit the variation in the stocks of the phytoplankton. This might be the proper use of the presence of the green color whole a year in the Rani Tal. The tropical Lake generally supports the higher mass of the algae but shows the low species diversity. The tropical Lake which is eutrophic in the nature contains the continuous algal bloom of the algae throughout the year. This floating mat of the algae on the water surface manifest as barrier to diffuses of atmospheric Oxygen to the water and the Oxygen produced by them largely escapes to air (Agrawal, 1999). The lower amount of the dissolved oxygen during monsoon and in summer season

than the prescribed limit in the Rani Tal might be due high coverage of floating plants. The floating plants shade the water column and decrease the photosynthetic release of the Oxygen from the submerged plants and also reduce the dissolution of the Oxygen in water. In addition when their dead roots and body decayed the organic debris then shed to water, They adds to the BOD through decay (Agrawal, 1999). Water shows the high concentration of the DO at low temperature high rate of aeration and high dissolution rate from atmosphere. Lowest concentration of DO in the monsoon might be due to high rate of the decomposition of OM (Badge and Berma, 1985). The solid cover of the free floating plants *Lemna, Wolfia, Spirodella, Pistia* etc on the water surface may also reduce the dissolved oxygen content of the water. The solubility of the Oxygen in the water is the fluctuation of its temperature. The lower is the temperature of the water, greater will be the solubility of the Oxygen. DO equal to or in excess of 5 mg/lt is considered as good for the majority of fresh water organism (Adenji, 1986; Adakole *et al*., 1998; WHO, 1970; UN, 1995). Low DO is often associated with epizootic outbreaks of bacterial and protozonal infections in aquatic animals (Spotte, 1970). The label of DO present in the water is among most important factor of the water quality. If the sufficient amount of DO is not present, animals will be stressed becoming vulnerable to the diseases or parasite outbreaks or will die (Stickney, 1979). Nepal water quality Guideline, GoN, (2009) reported that 6-9 mg/lt DO is suitable for cold water species, 5-8 mg/lt for warm water and intermediate species. EPA (2005) also reported DO should not below the 5 mg/lt for aquatic and semiaquatic animals. All sites in monsoon season shows less then this range and some site in summer season also shows lower value then this range in Rani Tal. Presence of the DO in good quantity in water bodies had tendency to improve water quality by oxidizing positioning gases such as Hydrogen sulphide and Ammonium in to heir non poisonous form (Reshed *et al.*2003).

The increase rate of the respiration and the decomposition in turn decreases the oxygen in water and increase the rate of the suffocation and killing of the fish. (Agrawal, 1999). If the sufficient number of the DO is not present, animals will be stressed, becoming vulnerable to diseases and parasite outbreaks or will die (Stickney, 1979). Hatchlings of Crocodiles could not be out of this outbreak. Shrestha (1983) reported Crocodile need high Oxygen content water. It might help alternatively with increasing organism diversity and density in Lake. The Lake showed the low level of Oxygen in monsoon and summer season. According to Shrestha (2001), this might

help to cause the stress to the Crocodiles by reducing the aquatic diversity of organism. The low DO may stress the fish and loss appetite which directly affect fish growth and even fish kill at very low DO level (<0.05 mg/lt) fish showed mass mortality (Rai, 1988). DO below 5 mg/lt is considered to be insufficient for survivability of many organisms. Oli reported DO below the 2.5 mg/lit is considered as lethal to the fish community existing in the water body (Oli, 1996). According to UNESCO, DO below 3.5 mg/lt is likely to fatal for fresh water fisheries (UNESCO-IUCN, 2005). Level below 3 ppm is stressful to most aquatic organisms and level below 1-2 ppm will not support the fish (Field Ecology Lab, 2000). Same range below is observed at some sites of Rani Tal may cause killing of fish.

Chloride is common ion that has little biological significance in the fresh water it serves as a little marker for water quality movement and dilution (Brocks and Paffen, 1985). Hot season showed relative decrease in Chloride in Rani Tal, the relative decrease in the Chloride concentration during hot seasons especially in autumn may be due to the dilution after rainy season. Thapa, (2007) found relative decrease in the Chloride concentration during the hot period's especially autumn due to the dilution after rainy season. The highest value of it during the winter season may be due to reduction in water level. Chloride showed the negative correlation with Total Nitrogen and positive correlation with phosphate. High value of Chloride observed in monsoon season may be due to adding from surrounding through monsoon flooding. Low value in winter season might be due to low use by the plant community and less rainfall so that it can not be added through surrounding sediments. Summer season shows high value might be increase in water level.

Up to 40 gm/l Chloride content is adaptable to aquatic plants. Rani Tal showed the suitable limit according to this adaptance. Chloride in excess is pollution indicator. Chloride concentration of the fresh water is less than 10 ppm. It enters to water naturally from sedimentary source (Kegely *et al.* 1995). United state public health society reveals maximum level of Chloride to survive aquatic organism as 290 mg/lt. UN (1995) reported more than 350 mg/lt of Chloride is harmful for aquatic use and other demand of fresh water. Nepal water quality Guideline, GoN, (2009) reported that fish can survive at <600 mg/lt of Chloride. MPCA (2010) reported that for survival of the aquatic and semiaquatic animals the Chloride concentration up to 230

mg/lt as chronic standard and maximum standard -860 mg/lt is limitable. Rani Tal showed the concentration in limit to survive for Mugger Crocodile.

Hardness is a measure of alkaline earth elements such as Calcium and Magnesium in pond water. Hard water has a higher concentration of alkaline earths. Calcium and Magnesium are essential to fish for metabolic reactions such as bone and scale formation. Additionally, Hardness and Total Alkalinity can affect pH through interaction with the CO_2 cycle (Stevens, 2009). Hardness of 15 ppm or above may suitable to the organic compound (Swingle, 1967). The Calcium content of the water bodies fluctuates directly with bicarbonates and both of these moves inversely with carbonates and pH concentration. Pearshall (1930) and Zaffer (1967) have observed the direct relationship of Calcium and bicarbonates. The relation can be interpreted on basis of the dissociation of the Carbonic acid HCO^{3-} into H^{+} and HCO^{3-} bring change in concentration of pH in water. Increase in Calcium and Magnesium Hardness increase Total Hardness. Total Hardness is caused by the dissolved Magnesium and Calcium in water. Total Hardness in water affects the physiochemical and biological parameters. Lind (1974) reported Hardness of 100 mg/lt is common in Nepal. Nepal water quality Guideline, GoN, (2009) reported <15 mg/lt of Magnesium and 20-100 mg/lt of Calcium carbonate is suitable for aquaculture. High value of Calcium hardness observed in summer season in Rani Tal might be due to organic decompositions. The contents released from died mollusk shells also increase hardness of water (Khan and Chowdhury, 1994). Flooding from surrounding of the Rani Tal might contribute the addition of Calcium content in Rani Tal. Somewhat high content of Calcium and Magnesium observed at Rani Tal might be due to addition of the Calcium and Magnesium nutrient from surrounding. The water hardness of 15 mg/lt or above may be considered suitable for the animals and plants (Swingle, 1967). Lower than this hardness range was observed in winter season observed might threat for aquatic and semiaquatic animals like Mugger Crocodile. Rani Tal showed not such a high content of water of Calcium. If there high level of Calcium hardnes in water; it may cause significant effect on the crocodile when high Calcium water was consumed. Singh *et al.* (2001) noted rubbery snout and hunch back condition occurrence in the captative Muggers due to the high level of the Calcium presence consumed by Crocodile.

Alkalinity is water's ability to resist changes in pH and is a measure of the total concentration of bases in pond water including carbonates, bicarbonates, hydroxides, phosphates and borates. These bases react with and neutralize acids, buffering changes in pH. Carbonates and bicarbonates are the most common and important components of alkalinity. Water with high alkalinity and similar hardness levels has a neutral or slightly basic pH and does not fluctuate widely (Stevens, 2009). As seasonal fluctuation of Alkalinity occur in Rani Tal. The seasonal fluctuation of the Total Alkalinity value might be due to the photosynthesis macrophtes and algae (Mandal, 1979). The Lake water of Rani Tal was reported to be alkaline thought the year. Same condition was reported by Jayana (1997) in Beshhazari Tal of Chitwan, Nepal. Highest Alkalinity value observed in winter season may be due to not consuming of bicarbonates in the Lake which might from sorounding water in monsoon seasons. High Alkalinity observed in monsoon season might be due to the addition of bicarbonate salt from surrounding during Lake body due to flooding. Some what less value observed in summer season might be due to increase in temperature causing decrease in water level but not utilizing the bicarbonate contents by vegetation.

Higher value of the Alkalinity in the monsoon may be result of the decrease in water level by the evapo-transpiration and lack of flushing. Relatively low in post monsoon may be attributed to the flushing and dilution by rainfall along with runoff. Alkalinity of the water usually imported by presence of the bicarbonates, carbonates and hydroxides. The presence of the free CO_2 in an aquatic environment usually showed the inverse correlation with Total Alkalinity such relation also observed by Bastola (1999) in Begnas Lake.

An optimum level of Alkalinity provides good buffering effects to the pH swings that occur in water body preventing extreme diurnal pH fluctuation (Boyd, 1979). A total alkalinity of the 20 mg/lit or more is necessary for good community productions (Wurts and Durbow, 1992). Total Alkalinity showed the negative correlation with Chloride, Phosphate and Total Nitrogen content. Spence (1964), the water bodies are categorized in to different according to Total Alkalinity values as poor nutrients (1-15 mg/lt), moderately rich nutrients (16-60 mg/lt), and Rich nutrients (up to 760 mg /lt). According to this value, Rani Tal lies in rich nutrients categories. A Total Alkalinity of the 20 mg/l or the more alkalinity is necessary for good community production

(Wurts and Durborow, 1992). The high alkalinity in Rani Tal is indicator of good indicator of the community production. Jhingran (1975) reported pH value less then 8.3 mg/lt but more than 4.5 mg/lt has practically no carbonates. Alkalinity only occurs in absence of CO_2 an pH greater then 8.3 mg/lt. Bastola (1999) also reported Total Alkalinity of the water due to the fluctuation of the bicarbonates. Suspended dissolved OM and inorganic, matters are responsible to hinder light penetration (Stepanek, 1959). High value of TS, TDS and TSS were observed in monsoon season. TDS, TSS and TS reported to be much higher in monsoon season in Rani Tal might be due to the inflow of silt and sediments and other loads from surrounding. EPA drinking water quality standard for the aquatic and semiaquatic animals that more than 120 mg/lt is not desirable. According to this limit the water of Rani Tal was not suitable for aquatic and semiaquatic animals. (Nepal water quality Guideline, GoN, 2009) reported <50 mg/lt of the suspended solids are associated with problems of sedimentation and irrigation and <2000 mg/lt of Total Dissolved Solids and < 20,000 of total suspended matter (For turbid water species) is suitable for aquaculture (Nepal water quality Guideline, GoN, 2009). These factors denote Rani Tal is at high rate of sedimentation and siltation. Nepal Water Quality Guideline, GoN, (2009) also reported that TSS and TDS should not change by 15 and 10% during year. This chagement was occurred at Rani Tal. UN (1995) reported not maximum 60 mg/lt of TSS and TDS is desirable for most of aquatic fresh water use but Shrestha (1983) reported the high Total Dissolved Solids is important for survival and well existence of Crocodile. The present Total Dissolved Solids support the Mugger Crocodile according to Shrestha (1983).

Nitrate was the end product of the aerobic stabilization of the organic Nitrogen and found in water bodies are found in different forms like nitrites, ammonium and various organic forms. Nitrate in the Lake body is due to the denitrification of the OM, atmospheric Nitrogen and surface runoff of sewage, fertilizer and pesticides from nearby watershed and agriculture area (Lind, 1974; Hanna *et al.* 1979). The highest value observed in summer season might be due to the decomposition and degradation of the organic Nitrogen content in summer season due to temperature favoring. The lowest value observed in winter might be due to the intaking of this inorganic Nitrate content by the growing plants. Excessive consumption of the Nitrate by the phytoplankton in Lake decreases the Nitrate content in year Lake environment (Ruttner, 1953). It might be due to the decrease in the bacterial tendency of

denitrificaton and minimum surface runoff from surrounding. Nitrate mostly not hazardous for fish and aquatic life but precisely at high level then 50 ppm may be stressful some species excess algal growth may occur in excessive growth hence effect indirectly. Excess Nitrogen can cause hypoxia or low level of oxygen become toxic to warm blooded animals at higher concentration than 10 mg/lt or same under certain condition (Davis and Cornell, 1991). According to Tchnobanoglous and Schroeder, a level of 0.19 per m^3 can be lethal to fishes. In this context the water of Rani Tal was suiting for the survival of fishes and aquatic organism (Tchnobanoglous and Schroeder, 1985). The highest value observed in summer season might be due to the decomposition and degradation of the organic Nitrogen content in summer season due to temperature favoring. The lowest value observed in winter might be due to the taking of this inorganic Nitrate content by the growing plants. Nepal water quality Guideline, GoN, (2009) reported <300 mg/lt of Nitrate is suitable to almost fishes and <100 mg/lt Nitrate for livestock use For common aquatic ecosystem the Nitrogen should not vary by 15% of water body under local unimpacted condition of any time of year. Rani Tal showed such seasonal variation where value exceeds by half almost. UN (1995) reported that up to 10 mg/lt is important for fresh water need for aquatic and semi aquatic animals. In this context the Rani Tal showed suitable limit. Hence the value of Nitrate observed was found suitable for the living of Mugger Crocodile.

CO_2 present in the low concentration in the air. It is about 200 times more soluble in water than in the oxygen but rate of diffusion of the CO_2 in water especially rich in minerals of the 10000 times slower than air. CO_2 content depends upon the temperature of the water, depth of the water, rate of the respiration, decomposition of the OM, chemical nature of the bottom and geographical and physiological features of the terrain surrounding water CO_2 content increases with the increase in the temperature (Agrawal, 1999). The high CO_2 may act indirectly to pump mineral nutrient from sediment. On water column as it stimulates macrophytes growth nutrient uptake by macrophyte roots and translocation to shoots (Titus and Pagano, 2002). Free CO_2 is an important water quality parameters high concentration depresses the affinity of the fish blood for CO_2 and Oxygen and cause suffocation of the Fish (Spotte, 1970). Aquatic organisms are greatly affected when free CO_2 concentration in water exceeds 25 mg/lt (Yadav, 2002; Anonymous, 1973). CO_2 rarely cause the direct toxicity to the aquatic animals however high concentration of CO_2 lower the pH of the water body and lower the Oxygen carrying capacity of fish blood by lowering

blood pH at gills (Wurts and Durbow, 1992). The effect by which high concentration of the free CO_2 depress affinity of the fish blood to Oxygen is known as root effect and this may be significant in water system with low Oxygen tension and weak buffering capacities (Spotte, 1970). High CO_2 concentration in water is often associated with epizootic outbreak of the bacterial and protozonal infections in aquatic organisms (Spotte, 1970). In winter season, Rani Tal showed such situation, where, the level of CO_2 here observed might hamper the fish community to survive.

As Rani Tal was reportedto have high CO_2 content in winter season. The highest concentration of free CO_2 in winter season might be due to low utilization by macrophytes and low utilization by animal respiration or due to less use of the CO_2 by below cover of the phytoplankton and other surface plant cover or due to their growing season. Low value was reported in monsoon season in Rani Tal. Low value in moon soon and summer season might be due to increase in temperature, decomposition rate and respiration rate of living organism. Increase in temperature, decomposition rate and respiration rate of living organism help to decrease CO_2 content (Verma and Agrawal, 1988; Ruttener, 1953). Free CO_2 of the most aquatic ecosystem is seldom present in excess quantities because of its reactions with carbonate equilibrium and exchange in the atmosphere. Carbonate extends as threshold of all productions. CO_2 in water from carbonic acid H_2CO_3 dissociates into H^+ and Hco_3^- brings the change in the pH of water (Ruttner, 1953).

Emergent or the surface floating aquatic plants obtain CO_2 from the atmosphere which enters the stomata on leaves, while submerged plants must obtain CO_2 dissolved in the water only those bodies of water abundantly supplied with CO_2 support luxuriant growth of the algae. Although an adequate supply of the CO_2 ions essential for the development of superabundant water bloom, an increase in the physiology of fishes. High concentration of the free CO_2 is produced by the OM decomposition and respiratory activity of the aquatic plants and animals. Bastola (1996) reported higher concentration of the CO_2 in the Begnas Lake of the Kaski, Nepal by OM decompositions and respiratory activity of the plants and animals.

High concentration of the CO_2 depresses the affinity of the fish blood for oxygen and cause suffocation to fish (Spotte, 1970). The average value of the CO_2 more than 6 ppm is not suitable for the fish culture and other aquatic, sub aquatic and terrestrial

wildlife propagation (APHA *et a1*. 1997). Hence the value of CO_2 observed was higher then permissible limit hence was not considered suitable for Mugger Crocodile. Nepal water quality Giudeline, GoN, (2009) reported that up to 75 mg/lt of CO_2 is suitable for fish. The permitted level of CO_2 in water for survival of Aquatic organism is 4.0 mg/lt to 25 mg/lt (Jayan, 1997).

High BOD was found in monsoon season might be due to high organic load flooded from surrounding with high microbial load. Winter season showed somewhat low BOD might be due to low OM content. Nepal water quality Guideline, GoN, (2009) reported that BOD should be less than 15 mg/lt for aquaculture. According to UN (1995), 5 day BOD should not above 7 mg/lt for common aquatic use by organism and other aquatic and semi aquatic use. Almost higher BOD than this range was reported in Rani Tal showed water was not desirable to drink by aquatic and semiaquatic animals in almost all season. Hence was considered not suitable for the Mugger Crocodile.

Surface water contains Total Ammonia of typically less than 0.10 mg/lt as Nitrogen. Total Ammonia concentrations measured in surface water are typically less than 0.2 mg/lt N but may reach 2-3 mg/lt N (WHO, 1996). High value of Ammonia in Rani Tal in summer season and monsoon season observed might be due to the addition of nutrient from surrounding and heavy decomposition of the organic material. Ammonia ranges site wise as lower occurrence than prescribed limit by WHO as Ammonia/Nitrogen in Rani Tal. Nepal Water Quality Guideline, GoN, (2009) reported 0.25 microgram per litre is suitable for cold water fish and 0.30 microgram per litre of Ammonia is suitable to warm water fish. MPCA (2010) reported that for survival of aquatic and semiaquatic animals, more than 0.04 mg/lt of the Ammonia is harmful in aquatic body. Summer and winter season in Rani Tal showed somewhat high range than this criterion may be harmful to aquatic and semiaquatic animals, hece was considered not suitable for Mugger Crocodile.

Phosphorous is commonly accepted as the most controlling nutrient in the freshwater Lake ecosystem (Schindler, 1975). The Phosphorous is an essential component of the energy and seems to be limiting factors. Phosphorous is biologically active element that comes from metabolic synthesis decomposition other than leaching of phosphate rocks, thus is good indicator of the water pollution (Lind, 1974). It increases the

growth of the blue green algae. Oligotrophic Lake frequently has 0.001 mg/l of the Phosphorous. The lowering of this results in to the release of the more Phosphorous sediments on water (Agrawal, 1999). Phosphorous occurs in natural water body as phosphate. Orthophosphate applied to the agriculture or residential cultivated land as fertilizers which are carried to surface water with storm runoff. Organic phosphates are formed primarily by the biological process. They are contributed to the sewage organic wastes. Phosphates are limiting nutrients which are discharged as row or agricultural drainage. Enrichment of Lakes and reservoirs with plant nutrients, particularly Phosphorous leads to eutrophication accompanied by degradation of water quality (UNEP-IETC, 1999). High seasonal variation in phosphate was obtained in Rani Tal. The seasonal variation of the Orthophosphate of the Lake is due to the fluctuation on the surface run-off, weathering of rocks, soil decay, and mineralization of the plant and animals remains (Kennan and Jobs, 1980). Eutrophication is natural aging process of Lakes that may be accelerated greatly through human activities which is referred to as cultural eutrophication (Masters, 2004). The end of nutrient enriching process occurs when the Lake becomes so shallow, and so chocked with living matter that it becomes hypereutrophic (Watt, 1973). Yoshimura (1937) used the Phosphorous –p as indicator and classified >0.02 mg/lt as eutrophic and below that as oligotrophic. According to this standard eutrophic Lake and from standard of Forsberg and Ryding (1987), Rani Tal lies in hypereutrophic Lake (Appendix 2).

Rani Tal showed somewhat large amount of Orthophosphate and Total Phosphorous during whole year. This might somewhat may be due to the high level of phosphate content in the surrounding and bottom soil. The bottom geology was found to be rich in the nutrient content. It may be due to decomposition of OM content. Heron (1961) has indicated that the phosphate increase may be due to decayed phytoplankton and concentration of zooplankton etc. The high Phosphorous in summer season may be due to resulting from higher consumption of macrophyte according to Zutshi and Vass, (1973). The increase in the phosphate content in Rani Tal may be due to the high decomposition rate of the OM, high nutrient addition from surface runoff and decay and mineralization of the plant parts. The concentration of the Total Phosphors in the water body seldom exceeds 1 mg/lt even in highly eutrophic water (Boyd, 1979). But Rani Tal showed higher than this range of Total Phosphoropus. The highest value was obtained in monsoon and summer in Rani Tal might be due to the microbial degradation of Total Phosphorous by bacteria what is collected by flooding

in the Lake in monsoon season. The lower value obtained in winter. The lower value of the phosphate level in winter might be due to use of the nutrient by phytoplankton (Gachter *et al.* 1974). Nepal Water Quality Guideline, GoN, (2009) reported 0.6 mg/lt of Orthophosphate suitable for aquaculture use. According to DHM, (1996) Orthophosphate concentration above 0.1 mg/lt is indicator of pollution. Nepal Water Quality Giudeline, GoN, (2009) also reported that the concentration of phosphate should not be changed by 15 % at any time of the year. This percentage change was occurred in Rani Tal. UN (1995) reported 0.4 mg/lt is maximum for freshwater needed by aquatic organism and semiaquatic animal for drinking. Rani Tal showed the water comprises more than this limit.

Although Lake bottom showed high amount of the Potassium content in Rani Tal but very low amount of Potassium found in Rani Tal in context to Lake bottom. The concentration of the Potassium contents in the natural surface waters is much smaller than the Sodium ones despite the fact that both elements are present in lithosphere almost same quantity and the solubility of the Potassium salts in the water is better than the Sodium salts (Stanley, 1993). The higher concentration of Potassium occurred during monsoon might be due to addition from Lake surrounding burnt OM and ash content. Very high amount of the Potassium is harmful for most of aquatic and other semiaquatic animals. Sodium content was found almost higher in Rani Tal in all season. Increase in the blue green algae *Anabaane*, *Nostoc*, *Anacystics* in eutrophic water may in part be associated with an increase in Sodium contents in the Lake (Stanley, 1993). Arsenic also was not reported in Rani Tal. UN (1995) and Nepal Water Quality Guideline, GoN, (2009) and reported up to 0.05 mg/lt of Arsenic is desirable for fresh water use by organism and other purpose. EPA drinking quality standard for semi aquatic and aquatic animals is maximum 0.05mg/lt to present in drinking water. Not occurrence of Arsenic might be due to absence of Arsenic content nearby surrounding rocks and soil.

Rani Tal showed almost higher productivity in whole year round. The highest value in winter season might be due to high Oxygen saturation. When DO is more the primary productivity also is more (Odum, 1996). High Alkalinity found also represent high productivity of Lake. Higher ratio of the bicarbonates over carbonates can be used as an index of the higher productivity (Khan and Quajum, 1996). The Carbonate formed after Bicarbonate decomposition. Frequently precipitate as Calcium Carbonate and is

deposited as submerged plant part giving them the coarse texture in the *Chara* and other plants and increase their survival against grazing. When there is decrease in pH and bound CO_2 there is increase in the predominance other algae.

Phytoplanktons are microscopic plants that produce most of the Oxygen and are the base of primary productivity in a pond. Phytoplankton depends on sunlight for photosynthesis and produce Oxygen during the process. Phytoplankton use Oxygen at night through a process called respiration. Extended periods of cloudy weather can cause a phytoplankton die-off, using oxygen during decomposition. If phytoplanktons are too abundant in a pond, the amount of oxygen used during night time respiration can cause Oxygen depletions for fish (Stevens, 2009). Kreb (1985) suggested fresh water communities' primary productivity is limited by the light and Phosphorous. In productive wetlands the presence of the *Chara*, *Wolfia* and *Uttricularia* in water are indicator of water pollution (Agrawal, 1996). Rani Tal showed the presence of them, indicating polluted with organic load.

Soil pH varies from acidic to alkaline in year almost with little change. pH in monsoon season ranges from 6.7 to 7.3 almost little fluctuation from neutral point. The acidic range might be leaching from site soil and alkaline condition might be due to high decomposition and microbial activity.The Conductivity ranges high in Rani Tal. High Conductivity in soil might be due to the high salt concentration and nutrient content.

Soil texture analysis ranged from clay to sandy caly to clay loam in bottom soil. Clay loam has highest water holding capacity and sandy loam has lowest water holding capacity. Young (1976) reported that sandy soils hold less OM than clays by about half as between a sandy loam or loamy sand. Sediments play the significant role in the process of the eutrophication of the Lakes. The clayey nature of the Lake is associated with the coating of the fine grained particulate OM which provides highly active physicochemical side for both adsorption and desorption of the Phosphorous and the wide range of the trace metals and organic pollutants of the low solubility (UNEP-IETC, 1999). Clay turbidity in ponds is one of the most common quality issues we address however; water quality can be affected through the interaction of many factors (Stevens, 2009).

Seasonal occasional depression in water content in Lake might be due to the atmospheric climatic change, irregular pattern of rainfall and temperature. Soil OM for Bottom and Site soil ranges very high in Lake bottom ranges from might be addition from surrounding flooding water which carries large number of nutrient content in monsoon season. The winter season and summer season showed lower than monsoon but high concentration of OM might be less use by phytoplankton and surrounding macrophytes. The Total Nitrogen ranged high in monsoon season. In winter season and summer season, it ranged low might be less used by phytoplankton and less contribution to the water content. There also high available phosphate was reported in Lake Bottom in all three seasons may be due to contributing from site soil and flooding surrounding.

Vegetation site soil texture ranged from clay loam to sandy clay soil with high water holding capacity. Pokharel and Sang Ho Jun (2008) made study on siltation and environmental changes of two wetland i.e Rani Tal & Solgaudi Tal in the SWR, western lowland Terai, Nepal) reported that Rani Tal's vegetation was comprised of mixture of the texture. As in Rani Tal vegetation soil texture ranges from clay loam to sandy clay soil with high WHC. Among the soil texture Clay loam has highest WHC and sandy loam has lowest WHC. Young (1976) reported that sandy soils hold less OM than clays by about half as between a sandy loam or loamy sand and sandy clay or clay. High WHC somewhat control the soil to be eroded in matter it contain high organic nutrients but high matter of the OM also help in eutrophication problem in Lake body. WHC of the soil plays important role in plant growth. WHC varied with texture and OM. Finer texture and greater OM reflects greater WHC (Joffee, 1953).

Vegetation sites of Rani Tal showed 4.9 to 5.2 of pH in present study. Pradhan *et al.* (1967) also reported soil of Singhpur of slightly acidic well drained loam underdrained by sandy loam and medium to high in OM content with average pH 6.0 to7.5 at surface soil. Present study showed somewhat lower pH than this. High pH in Rani Tal area soil was also given by Pokharel and Sang Ho Jun (2008).

High WHC somewhat control the soil to be eroded, in matter it contain high organic nutrients but high matter of the OM also help in eutrophcation problem in Lake body. Among the soil texture clay loam has highest WHC and sandy loam has lowest WHC. Young (1976) reported that sandy soils hold less OM than clays by about half as

between a sandy loam or loamy sand and sandy clay or clay. In Rani Tal, Pokharel and Sang Ho Jun (2008) revealed that the soil type was mixed with different soil texture classes. Soil in Sal forest area of the Rani Tal is very strongly acidic. Present study also showed that soil is highly acidic at vegetation site of Rani Tal area. Low OM and Nitrogen content in soil and high phosphorous in both the areas found by Pokharel and Sang Ho Jun (2008). Pradhan *et al*. (1967) found the 1.033 to 4.447 % of the OM content and 0.154 to 0.210% of Nitrogen content in soil of Singhpur nearby Rani Tal. Some what same pattern was found in Rani Tal area in present study as OM found presently was medium of 3.2 % about 4.2 % and Total Nitrogen presented of 0.32 % to 0.30 % which was somewhat higher range then determined by Pradhan *et al.* (1967). Pradhan *et al.* (1967) reported acidic range of soil in Kanchanpur district within range 5.7 to 6.9 and alkaline range of 7.2 to 8.9. Somewhat acidic range of soil found in Rani Tal area. Potassium ranged from 232 to 240 kg/ha from respectively and avaialable phosphate shows high range from 150 to 160 kg/ha in Rani Tal in present study. The same range of P and K found are 8.34 to 166.92 kg/ha and 150.08 to 290 kg/ha respectively by Pradhan *et al*., (1997) nearby Rani Tal area in Singhpur. But present study showed medium content of OM. Somewhat high Total Nitrogen percentage was reported at study area with the standard compared with (Pradhan, 1996). Pokharel and Sang Ho Jun (1996) also performed micronutrient analysis of the soil revealed that Mo, Zn, Cu and B content was low. In present study such analysis were not performed due to laboratory constraints. Here in Rani Tal high amount of the phosphate content and Total Nitrogen content might be cause in adding Phosphorous nutrients and high Nitrogen percentage in the Lake body. Rani Tal bottom soil showed high organic content but site vegetation soil had medium OM. In context site vegetation soil had not so much contribution on Lake Bottom to enrich OM. Golterman *et al* studied sediment of Lake and found that sediment affect the condition in water through respiration process because animals living in sediments play fundamental role in Lake bottom ecosystem. By extracting sediment core, information can be obtained on changes that have taken place in ecosystem (Golterman *et al.* 1983).

Sorrounding and Lake Vegetation is important factor to csause the change in morphometry of Lake and quality of water. As highly encroaching native species *Phragmites karka* has found to have encroached highly in the reed beds and coverage of the floating plants was almost high in the monsoons. As we know isands are

usually have many kind of encroacinhg and exotic species and more species were found at habitat edge (Meyers and Bazely, 2003). It was reported that these three species were always together because of the *Phragmites karka* was found to make areas easier for invasion by *Sachhraum spontanium, Erianthus ravvinnae.* As round the almost, the floating species on the Rani Tal had covered almost whole water body except the initiation of winter season this might be due to high addition of nutrients in Lake. The floristic and faunal diversity of the wetland influenced by the physiochemical parameters such as water transparency, conductivity, water temperature, pH and, nutrient status (CBIP, 1979). There found *Nymphea nouchali, Nelumbo nucifera, Trapa quadrispinosa* species together with alien species *Pistia straoites, Alternanthera philexoroids, Ludwigia sps.* Here *Nymphea nouchali, Pistia straiotes and Trapa quadrispinosa* have 100% frequency which is followed by *Nelumbo nucifera, Ludwigia adscendens* and *Lemna minor* with high frequency. *Pistia straiotes* have highest density followed by *Lemna* minor of and followed by the *Potamogaton nodusus* and *Wolfia globusa*. Highest density of *Pistia straiotes* help to decrease the Oxygen level and water quality degradation in Rani Tal. Floating community have the diversity index of 0.86 which is high diversity index shows the plant community is highly diverse.

In counter to the free floating organism estimation high coverage was found due to *Trapa quadrispinosa, Nelumbo nucifera, Nymphea nouchali, Pistia straiotes* and the species *Nymphea nouchali. Pistia straiotes* and *Trapa quadrispinosa* found to have 100% frequency with lowest frequency of *Hydrilla vercillata. Pistia straoites* found to be highest density and dominance followed by *Nymphea nouchali.* Among all sps, *Pistia* and other broad leaved floating species might have great impact on Lake. *Pistia straiotes* L. mats in water degrades water quality by blocking the air water interference and greatly reducing the oxygen level for the flora and fauna of wetlands in water, eliminating underwater animal such as fish.They also help to decrease birds' population due to difficulties in food availability. Grimmet *et al.* (2000) reported overgrown exotic plants in water body of Nepal declining bird population. Smilarily, due to high growth of alien and native invasive species, Chhetri (2006) had also reported decrease in wetland dependent bird species in Beeshhazari Lake.

Thick and intensive mats can block both sunlight and air from leaching water surface (Tiwari *et al.* 2005)**.** Tiwari *et al.* (2005) also reported IASs reduce abundance of the

native species and may alter the community structure and ecological processes such as nutrients cycling, energy flow or hydrodynamic property of the particular ecosystem. The introduction of the *Ipomea carnea ssp fistulosa, Altenanthera philexoroids, Echormnia crassipes, Myriophylum aquaticum and Pistia straiotes* influence wetland environment by reducing the DO level and trapping of sediments changes in habitat structures, water quality, food web structures and fish diversity (Tiwari *et al.,* 2005).

The invasive species like free floating macrophytes which occur submerged or on the surface exhibit great diversity in morphology and habitat like *Lemna, Pistia, Eichornia, Chara* etc. The high development of these plants can result in the excessive loading of the OM and nearly total attenuation of light below the surface. The high nutrient content behind Rani Tal might be due to these species presence. As, it causes several reductions and depletion of DO, can result loss of invertebrates and fishes (Wetzel, 2001). As Tiwari *et al.,* (2005) made inventory and assessment on invasive alien species of Nepal reported *Alternanthera* as medium risk posed species in Nepal grow in Lake and marshes of high nutrients content. The plants can form mats that extend over water surface even to support weight of person. The mat disturbs the natural ecology of the wetland site by reducing light penetration and crowding out of the native species. Serious infestations can create anoxia, diseases and good breeding ground for the mosquitoes.

Monsoon showed somewhat high depletion in DO in Rani Tal. Reduction of low DO in monsoon seasons might be due to the high coverage of native and floating invasive plants coverage in Rani Tal. Beside this some free floating species contain high evapotranspiration ratio. Although the aquatic vegetation gives substrate to certain animals and provided the mechanical covers and aids for wildlife to escapes from natural predators (Bennett, 1970). But dense submerged and floating aquatic weds restricts light penetration, reduce photosynthetic activity of phytoplankton and cause serious deterioration of water quality (Boyd, 1979). The *Pistia straiotes* is one reported to be highest evapotranspiration rate of 19.9 mmd^{-1} (Brenzy *et al.* 1973) helps in Lake drying. Rani Tal was in hyper eutrophic condition. This condition of change from eutrophic to high eutrophic condition of Rani Tal might be due to changed by large covering of the species floating like *Pistia straoites* and other submerged species of plant growing. MC Eachern (1996) reported that Water

Hyacinth mat on Lake surface has change status of Lake from mesotrophic to oligotrophic level.

Macrophytes usually consumed by various aquatic animals. Macrophytes act as pump by adsorbing nutrient from the soil and then releasing them in to Lake Water. The macrophytes have significant role in water communities and influence physicochemical parameter of shallow water (Hutchinson, 1975).

The physicochemical parameter and biological characteristics of the water of Lake depend upon the nature of its bottom, growth of macrophytes, suspended particles and color of water. The physicochemical parameters of the water are basically important for decomposition, distribution and abundance of benthic fauna because interaction of the physicochemical parameters create either favorable or unfavorable condition for development of particular biotic element (Dutta and Mulhotra, 1986). Rani Tal comprised of high structural diversity of the marsh and sorrounding vegetation for supporting many species of wild fauna. Greater structural diversity of the Lake vegetation leads to the greater wildlife species diversity (Dix and Smeings, 1967). Similarily *Phragmmites karka* was highly encroaching the Lake body. As eastern site of the reed beds of the Rani Tal were main region for the basking preference for large number of the Mugger Crocodile previously, since is being invaded by the *Phragmites karka*. It might be the decrease in the number of the Mugger Crocodile in Rani Tal area. *Phragmmites Karka* is common reeds in Nepal similar to the *Phragmites austrialis* as cosmopolitans occur in Europe, Asia and America and Australia (Tewsksbury *et al*. 2002). It is native to the Europe where red beds are important for many migratory birds' species. In Atlantic coast *Phragmites* increasing dramatically in both fresh and brackish wetland and monoculture. They are associated with decline in the water birds and wetland wildlife. Rapid extension of the *Phragmites* in recent years and paucity of these native herbivores feeding on this expanding population suggests a new introduction. Huge spreading *Phragmites* is due to increase through rhizomes and with sexual reproduction by wind/self pollination. However, recruitment from seed is thought to be low (Tewksbury *et al.* 2002). *Phragmites karka* was with high density in Rani Tal may reduce the amount of birds species present. For e.g. population of yellow warbler (*Dendroica petechia*), Bells Vireo (*Vireo belli*) and several other bird species that depends on the Cotton wood, Willow, Mesquite and other native plants have been reduced or extirpated in Tamarix

infested areas (De Loach, 1990). After plants die rain washes crystals in soil creating saline condition under which seedlings of most plants sps can not survive (Vivrette and Muller, 1997). High evaporation rate of *Phragmites karka* cover help in drying Lakes (Wetzel, 2001). Seasonal depression in water of Ran ital might be due to effect of *Phragmites*. A simple expected outcome of successful establishment of introduced sps would be a negative correlation between plant diversity or cover and species richness (Watt, 1973). Perhaps the native species were affected by the disturbance and its decline prior to the survival of the species that later become invasive (Meyers and Bazely, 2003).

The coverage of IAPS up to 70 % indicates that the habitat is degrading for the wetland-dependent birds. Rani Tal shows higher than this coverage. These results indicate that bird species composition depends on the degree of invasion by invasive alien plant species and availability of open water body. The similarity in species composition decreased significantly with the increasing coverage of IAPS. The wide spread distribution of IAPS has a significant role to decline the number of bird species and total individuals through reduction of the potential foraging ground for water birds. There takes a decrease in the abundance of the wetland bird species with the increasing invasion of the IAPS. Rani Tal also comprised of these invasive floating species which might be hampering to birds fooding and other aspects as most of the birds species need the open water body, as floating plants coverage in Rani Tal was about almost 95% during growing season. *Pistia Straiotes* are growing insignificantly in many wetland of Nepal helping decreasing bird species of wetland dependents (Shah and Shah, 1999).

As there was high invasive plants coverage in Rani Tal, Invasive species helps in favoring the habitat condition for combination of by other species. The process of soil formation that may occur during facilitation is primary step in primary succession which invasive species after soil processes, they may create the change that have potentiality to radiate through ecosystem (Ehrenfeld and Scott, 2001). Presence of invasive species might cause change in soil property. Soil properties that change in presence of the introduced species include soil biota, bacteria and fungi (Belnap and Phillips, 2001) and Nitrogen cycle (Scott *et al.* 2001). Talking to above all perspect the overgrowing of alien and native invasive species found to have disturbed the Lake

and Lake dependent organism. This threat to organism if caused is direct threat to Mugger Crocodile being top carnivorous of ecosystem.

Talking to the climbers, somewhat high diversity with high canopy coverage found when visual observed. Many climbers and tree species have given surface shading to Rani Tal. Plant community at Site 1 had found the highest diversity index of approx 1 which indicate highly diverse community dominated by *Shorea robusta* and kukurdiano. Approximate species diversity index of 1 was reported at Site 1 and 2 denote that the community was highly diverse. Site 3 also showed high diversity index denoted that the plant community in Rani Tal was highly diverse and in leading age of succession. Density varied plot to plot. Density is influenced by various factors including elevation, soil type, dominant and associated species and human activities (Shrestha, 1998). The vegetation around Lake contribute for the maintenance of the hydrology/decomposition and maintain overall good health of the wetlands system. The high density of vegetation around Rani Tal is good for many animals to survive. Adjoining vegetation provides habitat, food and energy to the faunal and microbial communities (Shah, 1997). Surrounding vegetation in the Lake was very important for controlling erosion, giving substratum and shelter for many organism, and providing nutrient balance in the Lake. Rani Tal containing high diversity of the terrestrial vegetation played vital role in maintaining the Lake. In North western site it was reported that the Lake surrounding vegetation and grass vegetation has controlled the erosion in greater extent (Field survey, 2009). Khadaka (2009) also reported surrounding vegetation in Jhilmila Tal have reduced the erosion rate and sedimentation.

Vegetation composition and structure influence type quantity and nutritive quality of the plant food available, density and structure of cover, type of substrate, water chemistry etc. For the reasons vegetation analysis have widely used to assess how wetland functions. (Campbell *et al*. 2002). Rani Tal comprise of high structural diversity of sorrounding vegetation for supporting many species of wild fauna. Greater structural diversity of the Lake vegetation leads to the greater wildlife species diversity (Dix and Smeings, 1967). High amount of biomass composition was found in Rani Tal from surrounding vegetation. High amount of surrounding biomass also contribute the addition of organic materials in the Lake body. This litter content might help in addition of organic content in Rani Tal by with taking with monsoon water.

Monsoon water will certainly carry it to Lake causing overload of the organic nutrients

Shrestha (2001) reported basking promontories of rock or elevated cliff need for Crocodile to water body and nearer area. He mentioned that exposed windy sand banks with steep sand bank bars inclined to angle of the 45 to 60 degree are need for basking. Mugger Crocodile supports the plant coverage with proper openings for basking. Rani Tal has such sufficient reed beds but is heavily encroached by *Phragmites karka*. Rani Tal also supports the loose humid soil. As loose humid sand banks and mud flats ideal for egg depend, incubation nesting etc (Shrestha, 2001). Rani Tal supports sufficient vegetation cover in surrounding. As river bank covered with extensive vegetation to meet shade and cover needs are important to survive the Crocodile (Shrestha, 2001).

Rani Tal was being closed by the small height closed embankment by controlling down flow where water flowed ever and supported much wildlife although dam in Rani Tal had given many corridoir for sustaining of much wildlife like major carnivores as tiger (Lohani, 2000). But it might have hamper the other free moving wetland depend species like Crocodile for downward water bodies like Bahuni and Chaudhara river as reported from Focus Group Discussion and interviews. The result from questionnaire survey also reported that there was decrease in the number of Crocodile in Rani Tal after construction of the closed dam. Beside this any harm upon other species also harms the Mugger Crocodile as it being top carnivores. Many scholars have made studies on such facts. Bishop (1979), Blyth (1980, 1984) and Yadav (1989) have reported disappearance of the many stream benthic fauna species like caddis fly, Mayfly and Stone fly after construction of dam. When dam is built in flowing water the downward vegetation become xerophytes and develops toward climax community. In case of large river like Mahakali, and Karnali, the construction will be question for surviving of Mugger and Gharial Crocodiles (Shah and Shah, 1999).

The wetland dominated by the surface water inflow and outflow reflects the chemistry of associated river or Lakes. Those wetland that receives surface water or the ground water inflow, have limited outflow or lose water primarily to the evaporation and evapotranspiration have high concentration of the chemicals and lower concentration

of the chemicals are in the wetland which receives water primarily from precipitation and loses water by way of surface water outflow and seepage to ground water (Winter and Woo, 1990). High concentration of the Chemical contents found in Rani Tal may be of same reasons, as Rani Tal had these all aspects. As wetland receives water from more than one source hence resultant chemistry is composite chemistry of various sources (Siegel and Glaer, 1987). Wetland dominated by the surface water inflow and outflow reflect the chemistry of rivers or Lake. That wetland that reduces surface water or ground water have limited outflow or lose water loss primarily to the evapo-transpiration and have high concentration chemicals (Winter and Woo, 1990).

Rani Tal is the Lake not having proper outflow is being checked by the dam it may action so increasing evapo-transpiration and decrease in the water level and further increase in the concentration of the chemicals which might change physiological changes in bottom soil and chemistry, alteration of bottom dwellers. Saud (2007) made study on the benthic fauna in relation to the physiochemical parameter in Kulekhani reservoirs, Makawanpur, Nepal found two group of the pollution tolerant benthic fauna like Oligocheata and Chironomideae. He concluded the pollution tolerant organism in reservoir might be due to changes in the physicochemical parameter in bottom, habitat alteration from stony to muddy, changes to the water regimes high depth and frequent water level fluctuation. He found the depletion in reservoir due to the combined effects like water level fluctuation, Oxygen depletion, and thermocline breakdown of the stratification, Interaction with exotic species and habitat alteration with exotic species and habitat alteration. Although embankment/dam had built to increase the level of water but it had seemed to giving place for *Phragmites* and other plants to invade by addition of sediments and OM in Lake.

The Rani Tal area according by Scot (1989) was 220 ha. BPP (1995) reported its area of 20 hector with 200 hectare water coverage. Later by Suwal and Shrestha (1992) reported Rani Tal with area of the 150 ha has turned in to the grassland due to vegetation succession. Bhandari (1996) reported that Rani Tal have area of the 11 ha. Lohani (2000) reported 18 hectare of Rani Tal has reduced to the 7-8 hectare due to encroached by *Phragmites karka*. Similarly, Bhandari (2009) reported Rani Tal having area of 11 hector in his ‘Preliminary inventory of Nepal’s wetlands’. Present researcher could not measure the exact area of Rani Tal due to heavy coverage of

Phragmites karka and large numbers of reed beds difficult to reach. Discussing on these trends all data shows the pattern of degradation. If the pattern is true the Rani Tal will disappear within about minimum 10 year. High decrease and encroachment in the area of Rani Tal was reported (Field survey, 2009). With prospect of climate change and irregular heavy rainfalls park people believe again shifting of the Chaudhara River in the Rani Tal. If such happen it will destruct large ecosystem of Rani Tal. Erratic drying of the Lake during drought might be due to the climate change as change in temperature and rainfall pattern.

Poisioning is the main factor to cause destroying of Lake organisms. As illegal approach and poisoning on the Rani Tal was made by the Local Tharus. It might be factor for decrease in the Mugger Crocodile abundance in Rani Tal by reducing the diet content. Poisoning cause bioaccumulation and affect the whole of the food chain. As water could not outflow of the dam, it persists for long terms in Lake body and affects the Lake biodiversity. The poisoning activity might hamper the survivability of hatchlings of Mugger Crocodile and other biotas.

Since, Rani Tal showed poor water quality almost especially in monsoon season with degraded Oxygen content, high Nitrate, and phosphate content. Poor water quality, with high nutrient contents helps to cause breeding of much fungus, bacteria's and viruses which can cause infections to the aquatic and the animal depending upon particular wetland. Lal (1982) reported the snout bones rotting and falling of teethes in Gharial hatchlings due to myotic infections. Most of the nutrients are carried to the wetland site from surrounding due to the surface flowing. Many of fungal and bacterial species carried to wetlands from surrounding and there they breed and cause toxicity and diseases in water and land animals depend on wetlands. Maskey reported 605 of Gharial died of myotic infections particularly in monsoon season due to poor water quality and extreme humidity favored (Maskey, 1989). Excessive overloading in the Lakes may cause the outbreak of the fungi, bacteria and, these are the main agent to cause many physiological disorders in the Crocodile like in Kidneys, Spleens, and Livers diseases (Gaire, 2007). Many disorders might occur due to poor water quality of wetland. Wataru reported that the environmental change, change in water quality, change in temperature cause abnormalities in Crocodiles (Wataru 1976). Extreme calcium present in the water might harm the Mugger Crocodiles when consumed. Singh *et al.* (2001) noted rubbery snout and hunch back condition

occurrence in the captative Muggers due to the high level of the calcium presence consumed. Similar conditions were reported by the Huchzermeyer, in young captative Nile Crocodiles, *C. niloticus* (Huchzermeyer, 1986)**.** Since Rani Tal is being tagged by the dam causing watyer quality to be poor. Poor water quality in monsoon season causes the significant death of hatchlings (Maskey, 1989). The water here could not outflow due to small closed dam, hence reserving much of nutrients day by day which make favor to grow infecting microorganisms to cause disease or infections in hatchlings. Mishra *et al*. reported low level of water without replacement for long time causes the infection by bacteria's to the hatchling of Crocodiles (Mishra *et al*. 1993).

Physiochemical factors are primary factors for the presence of fish community in water body, various other factors such as ongoing ecological changes of aquatic ecosystems physiological nature of the biotic community also might have effect on distribution of fish fauna in water body (Pandey, 2002). This fluctuation can cause food shortage to Crocodile.

The fluctuation of the water quality disturbs the functioning of aquatic system by disturbing the fooding of phytoplankton which ultimately decreases of common fish. It means it also disturb the food chain of Mugger Crocodile. Sedimentation and siltation processes help to decrease the Lake area as well as growth and survival of water fauna and flora. Similarly high nutrient status of Lake also helps to grow of the increased flora as lead to eutrophication. This process also leads to the Lake deterioration. The water quality if not in permissible limit it directly degrades the Lake hence effecting flora and fauna or disturbs the food web structure. The invasive species effects almost all living body of the Lake hence as Crocodile is one of the major carnivores in ecosystem if the quality of the Lake are enhanced it will directly harm the Lake depend Crocodile by declining in number of food materials for carnivores.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Present study concluded that the population of Mugger Crocodile in Rani Tal was 4 presently. There reported about 59-98 estimated number of Mugger Crocodile in SWR. This number of Mugger Crocodiles present in Rani was depressive number than observed in past by respondents. Regarding to status of Lake, the water quality and other environment was not good to survive for Mugger Crocodile. The decrease in trend of population was found after the Dam (embankment) construction. The main reasons behind the depletion in number of the Mugger Crocodile were the dam impact of obstruction in free flow, presence of alien and native invasive plant species and covering of sandy and muddy soil bank by vegetation succession which is important habitat for Mugger Crocodile. Illegal fishing with poisoning, water quality deterioration and decreasing area of Rani Tal was other threats. The encroachment of the invasive species was found to have hampering watering and fooding activity of animals. As Mugger Crocodile is the top carnivore, the change in any aspect in the producers and consumers will directly harm the Mugger Crocodile.

Regarding water quality status, Rani Tal was found to be high phosphorous content and Nitrogen, reveals the hyper eutrophic condition of the Lake. Parameters like seasonal depression in Oxygen, high Total Hardness, high CO_2, high Orthophosphate and high BOD and Amonia was found to be threat to Mugger Crocodile. The major problem in the Rani Tal was both addition of the nutrients and sediment from the surroundings which was leading the extensive growth of the macrophytes. The increase in the nutrient is also closely associated with the external loading from the surrounding forests and soil, as surrounding soil and Lake bottom was found to be rich in the Nitrogen, Phosphorous and organic content. Bottom sediment one hand was helping for addition of nutrients in the Lake and on the other hand, it was giving basement for many aquatic species. The *Pistia straiotes, Nelumbo nucifera, Nymphea nouchouli, Wolfia, Trapa quadrispinosa, Lemna, Alternanthera philexeroids* and submerged species like *Chara* were also responsible for the degradation of Lake. Similarly, highly encroaching species like *Phragmites karka* found to have given platform to invading *Sachhraum spontanium, Erianthus ravvinnae* and other plant species. It was reported that these three species like *Phragmites karka, Sachhraum spontanium* and *Erianthus ravvinnae* were always together because of the *Phragmites*

karka was found to make areas easier for invasion by *Sachhraum spontanium, Erianthus ravvinnae* and others. The dam was responsible for accumulation of organic debris hence increase in coverage of macrophtes and other floating species. Similarly, encroaching species like *Phragmites karka, Trapa, Nymphea, Nelummbo* etc and other high diversity surrounding vegetation were responsible for the addition of OM to the Lake hence decreasing area of Rani Tal, where 200 ha area has been reduced now to 7-8 ha only. Climber community is found to be dominating by *Bahunia valli* and *Dioscorea bulbifera*. Plant community in Rani Tal was highly diverse and in leading age of succession. High density and diversity range of plant was reported to be adding the the biomass content to lake hence causing indirect threat to Mugger Crocodile by adding OM content

Recommendations

The following recommendations were made for conservation of Rani Tal and Mugger Crocodile.

1. Strict Act and Implement of the Crocodile conservation should be done with special protection agency in SWR area.

2. Mugger Crocodile should be prioritized same as to the Gharial. Donor agencies should also focus on the Marsh Mugger due to its vulnerability and joint effort of the NGO and INGO should be created to conserve Mugger of SWR.

3. Monitoring of the Marsh Mugger should be done and the main finding regions of the Marsh Mugger should be noted in SWR and even for whole country.

4. The Lake environment of Rani Tal should be improved with replacing huge growth of *Phragmites* other encroaching species and creating sandy and Muddy soil bank there.

5. Recharging, disiltation and restoring programs should be done in Rani Tal to avoid seasonal depression in water.

6. The Periodic removal of invasive alien plant species like IAPs and INS along with other floating vegetation should be done with Mechanical, Chemical or biological control. It will help in providing open water surface for the animals and submerged plants. Periodic removal of IAPS and INS would allow the wetland dependent birds and other below water animals to enjoy their habitat in full extent, so it should be continued.

7. Site of inlet and outlet for the Lake should be reviewed time to time. A comprehensive long-term management Plan for the Conservation of Rani Tal is essential and should be formulated involving various stakeholders very quickly concentrating on the conservation of Lake, its animals and plants.

8. As Reserve office was planning to dig canal to Rani Tal for recharging. During this siltation and organic debris almost should be checked as much as possible.

9. Extensive research on food avaibility of Mugger and its all round status in Rani Tal and SWR should be made.

10. Conservation awareness among local people and ethnic community should be created if possible.

11. Effective security system should be conducted to control poaching and illegal collection of resources and illegal entrance to reserve area.

12. If possible local people and ethnic community nearby Rani Tal should be provided with incentives for living and empowerment training so that they could not have to depend on reserve even for fooding.

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Annex: 20

Model of Questionnaire

Name of Respondent: …… Age: …….. Sex: Male/Female

Occupation: ……

Address: ……

Questionnaire for SWR members and Frequent visitors to Rani Tal

1. Have you ever visited to the Shuklaphanta Wildlife Reserve area?
   a) Yes b) No

2. How long have you been going to Reserve's area?

3. Have you visited wetland sites of Reserve?
   a) Yes b) No

4. How many wetlands sites inside Reserve have you visited? Please name them.
   a) …….. b) ……c) …….d)……

5. Have you ever seen/heard the Mugger Crocodile in those areas?
   a) Yes b) No

6. If yes, what are the wetland areas where Mugger Crocodile abundant in your view?
   a)……b)……c)…….d)……

7. How many Mugger Crocodiles usually abundant in those areas daily in range?

Name of wetland	Number of Crocodile

8. Have you ever heard the poaching/killing cases of Mugger Crocodiles in/ outside the Reserve? If have heard, how many such events take place?

Events in year heard	Events total listened till now

9. (i). If there takes poaching of Mugger Crocodile, what are the main ways to enter the Reserve area in your view and what are sites of poaching?

   a)…… b)…… c)…….. d)……

   Sites of Poaching-a)…….b)…… c)……

   (ii) From these places how might they able enter the reserve's area?

10. It is heard that lakes of SWR are being encroached by the invasive species, how much year did it take of invasion?

Name of plant	Starting of invasion	Place of invasion

11. Which Lake in SWR have you heard was most encroached by the invasive species?

12. Do the invasive species affect biochemistry of the lake?

    a) Yes b) No

13. Had these invasive species affected the living standard of the Mugger Crocodile in lakes of SWR?

    a) Yes b) No

14. Have you ever heard the leaving of the reserve area by the Mugger Crocodile?

    a) Yes b) No

15. In your aspect, how many events are there concerning Mugger Crocodile had leaved Reserve area?

16. (a) Have you heard any hindering activity caused by publics to the Mugger Crocodile when leaving Shuklaphanta?

    i)Yes ( ) b) No ( )

    b) If yes mention what action was performed? (……)

    (c) Have you heard/seen the collection of the eggs of the Mugger by locals?

    1) Yes ( ) 2) No ( )

17. If there is egg collection activity, especially which community and from where they used to collect and for what purpose they collect the eggs of the Mugger Crocodile?

Name of community	Purpose of Collection	Place of collection

18. a) Do you say Rani Tal in danger?

    a) Yes ( ) b) No ( )

    b) If Yes, how?

    (……..)

19. Do you say, there is good environment for the Mugger Crocodile to live at Rani Tal?

    1) Yes ( ) 2) No ( )

20. If there is not suitable environment, what can be done to improve it?

21. Is there decrease in the population of the Mugger Crocodile in lake area or same as previous? a) Same as previous ( ) b) Decreased than previous ( )

22. i) If inclined, what might be the cause of incline of the Mugger Crocodiles in this area?

    ii) If declined, what might be the cause behind decline of the Mugger Crocodiles in this area?

    a) Lack of proper basking place by *Phragmites* invasion b) Food deficiency

    c) Poor water quality d) Free movement of Mugger Crocodile controlled by dam/embankment e) All of above f) If any other please mention…… ……..

    g) Not Known

23. How much time it has gone about the invasion of the plant species in Rani Tal?

Name of plant	Time of invasion

24. Are there large invasive species of the plant before construction of Dam or after construction of the dam?
    a) Before Construction Large in Number ( )
    b) After construction Large in Number ( )

25. As there is closed dam in the lake, have you heard or seen any difference in the number of the Mugger Crocodile before and after dam construction?
    a) Yes ( ) b) No ( )

26. If there was a difference, how many are before and now?
    Approximate population before dam construction ( )
    Approximate population after dam construction ( )

27. Are the *Phragmites* and other grasses density increased after Dam construction or not?
    a) Not increased ( ) b) Increased ( )

28. Have you heard the Mugger Crocodile hunting cases in Rani Tal? If have heard, How many events have you heard till now?
    a) Total number of events heard till now ( )
    b) What might be the cause of such events?
    ……
    c) What might be the main entering paths to Rani Tal area for posing such events?
    1)…… 2) ……. 3) ……

29. What can be done for the sustainable conservation of the lake dependent faunas together with *Crocodylus palustris*?

Questionnaire survey for old dwellers of Rani Tal/ ethnic community nearby Rani Tal

1) Have you visited the Rani Tal any time when living nearby Rani Tal in past?
   a) Yes b) Not

2) If yes, how many times have you visited Rani Tal?

3) Had you seen any Mugger Crocodile at Rani Tal during your visit?
   a) Yes b) Not

4) If yes, how many Crocodiles had you seen there in daily average? Please, give in range.

5) Which sites were main basking places of the Mugger Crocodile at Rani Tal at past?
   a) East b) West c) North d) South
   e) NE f) NW g) SE h) SW

6) How were the Mugger Crocodiles mostly seen at Rani Tal?
   a) Adult b) Sub adult c) Hatchlings

7) Do you go frequently to Rani Tal nowadays?

8) If Yes, Have you heard/seen Crocodile population decreased/increased than previous?
   a) Yes b) Not

9) If decreased /increase what is difference in their number?

10) If number has decreased, what may be cause behind the decrease in Crocodile population at Rani Tal?

a) Lack of proper basking place b) Poor water quality c) Food deficiency d) Dam impact to free movement downward site for Crocodile e) All of above f) If Any other, Mention……

11) What do you think are the threats to Mugger Crocodile at Rani Tal, How can those threats be minimized?

12) Have you heard any illegal activity performed at Rani Tal?
a) Yes b) Not

13) If yes, what type of the illegal activity have you heard/seen at Rani Tal and other areas?
a) Fishing b) Fodder collection c) Animal hunting d) Egg collection of animals (like?.....)
e) All of above f) Not heard any events

14) Have you heard/seen poisoning for fishing at Rani Tal? If Yes, Which Community performs such?

15) How much did it take place of invasion by Narkat, Jaljambhu and Kumbhika in Rani Tal?

16) Is Rani Tal decreasing than previous or not, how much depth and area might have decreased than previous?
a) Depth decreased …….. b) Area decreased…….

17) What could be done for susutainable use of Rani Tal and its resources including conservation of Mugger Crocodile in your view?

The End

Annexes

Annex 1: Chemical Index after BACH (1980)

CI	Water quality class	Color Indication	Water rate pollution Level
0-17	IV	Red	Excessive pollution
17-27	III-IV	Orange	Very severe pollution
27-44	III	Yellow	Severe pollution
44-56	II-III	Light Green	Critical pollution
56-73	II	Green	Moderate pollution
73-83	I-II	Light Blue	Low Pollution
83-100	I	Blue	Very Low or low Pollution

Annex 2: Trophic state Classifications

Note: All units are in microgram per liter. Here TN means Total Nitrogen, TP means Total Phosphorous

Lake Type	OECD, 1982	Burns *et al.* 1999		Forsberg and Rydings, 1980	
	TP	TP	TN	TP	TN
Oligotrophic	<10	4.1-9	73-157	<15	<400
Mesotrophic	10-35	9-20	157-137	15-25	400 - 600
Eutrophic	35-100	20-43	337-725	25-100	600 - 1500
Hypereutrophic	>100	>96	>1558	>100	>1500

Annex 3: Soil nutrient criteria for Terai and Common Soil for Nepal. (Pradhan, 1996)

For Total nitrogen

Low% (< 0.075), Medium %, (0.075-0.150), High %(> 0.150)

Or

Very Low (<0.05 %), Low (05-0.1%), Medium (0.1-0.2 %), High (0.2-0.4 %), Very high (>0.45 %)

Available phosphorous

Low (< 26 kg/ha $P_2O_{5)}$, Medium (26-55 kg/ha P_2O_5), High (>55 kg/ha P_2O_5)

Or

Very low (<10 Kg/ha), Low (10-30 Kg/ha), Medium (30-55 kg/ha), High (55-110 kg/ha), Very high (>110 kg/ha)

Potassium
Low (<110 kg/ha K_2O), Medium (110-280 ha K_2O), High (>280 kg/ha K_2O)
Or
Very low (<55 kg/ha), Low (55-110 kg/ha), Medium (110-280 kg/ha), High (280-500 kg/ha), Very high (>500 kg/ha)

Soil Organic matter
Very low (<1%), Low (1-2.5%), Medium (2.5-5%), High (5-10%), Very high (>10%)

Soil pH
Acidic (<5.5), Slightly acidic (5.5-6.6), Stable or neutral (6.5-7.5), Slightly alkaline (7.5-8.5), alkaline (>8.5)

Annex 4: Raunkier's classification of frequency

Raunkier frequency class (%)	Frequency classification	Abundance
0-20	A	Rare
21-40	B	Occasional
41-60	C	Frequent
61-80	D	Very abundant
81-100	E	Dominant

Source: Raunkiers (1934)

Annex 5: Moisture content and Biomass of the litter

Sites	**Sample code**	**Fresh wt.**	**Dry wt.**	**WaterContent (%)**	**Average watercontent (%)**	**Biomass (w/A)**
1	A	160 gm	92.365	57.27	51.64	826.24
	B	140 gm	83.568	59.69		
	C	120 gm	45.561	37.96		
2	A	180 gm	96.573	53.65	49.37	789.92
	B	130 gm	84.473	64.97		
	C	183 gm	54.038	29.50		

Annex 6: Bottom soil parameter in monsoon season

Parameters	**Site 1**	**Site 2**	**Site 3**	**Site 4**
pH	6.7	7.2	7.3	7
Conductivity	402.3	420	421	513
TN	3.54%	5.34%	2.42%	1.45%
Available phosphate	420 kg/ha	533 kg/ha	425 kg/ha	417 kg/ha
Organic matter	11.2%	10.2%	10.1%	9.2%
Potassium	442 kg/ha	412 kg/ha	402 kg/ha	416 kg/ha
Calcium	11.3%	10.3%	10.42%	9.24%
Magnesium	6.03%	5.25%	3.29%	6.01%

Annex 7: Bottom soil parameter in winter season

Parameters	Site 1	Site 2	Site 3	Site 4
pH	6.5	7.0	7.4	7
Conductivity	342	375	354	345
TN	4.35 %	3.45%	0.932%	0.442%
Available phosphate	310 kg/ha	389 kg/ha	320 kg/ha	340 kg/ha
Organic matter	9.5%	8.5%	8.2%	8.0%
Potassium	340 kg/ha	320 kg/ha	312 kg/ha	361 kg/ha
Calcium	6.04%	8.25%	7.39%	5.45%
Magnesium	3.29%	4.95%	6.32%	4.29%

Annex 8: Bottom soil parameter in summer season

Parameters	Site 1	Site 2	Site 3	Site 4
pH	6.9	7.2	6.8	7.2
Conductivity	245	356	457	321
TN	4.4 %	3.45%	0.84%	0.47%
Available phosphate	318 kg/ha	315 kg/ha	325 kg/ha	317 kg/ha
Organic matter	9.2%	13.9%	10.2%	10.5%
Potassium	244 kg/ha	288 kg/ha	302 kg/ha	314 kg/ha
Calcium	10.3%	14%	11.2%	9.24%
Magnesium	5.04%	3.4%	4.2%	5.34%

Annex 9: Result of Site soil analysis

Parameters	Site 1	Site 2
pH	5.2	4.9
Conductivity	225	244
WHC	39%	37%
Moisture content	33.4%	32%
Organic matter	3.2%	4.2%
TN	0.32%	0.30%
Available phosphate	150 kg/ha	160 kg/ha
Potassium	240 kg/ha	232 kg/ha
Calcium	9.12%	9.04%
Magnesium	5.08	6.12

Annex 10: Average seasonal water quality of Rani Tal

Parameters	**Monsoon season**	**Winter season**	**Summer season**
Color	Muddy green	Yellow green	Muddy green
pH	7.2	7.17	7.3
Temperature	26.50	17.3	28.50
Conductivity	313.3	153	152.80
Transparency	---------	0.77	-------
DO (mg/l)	3.58	6.0	5.25
Carbon dioxide (mg/l)	8.48	33	12.80
Ca-hardness (mg/l)	48. 80	5.32	58.38
Mg-hardness (mg/l)	51.20	5.32	27.10
Total hardness (mg/l)	100	10.64 l	89.84
Chlorine (mg/l)	34.42	30.96	31.42
Alkalinity (mg/l)	116.4	139	116
TDS (mg/l)	625.60	600	443.4
TSS (mg/l)	690.40	560	237.6
TS (mg/l)	1328	1160	671
Nitrate (mg/l)	0.240	0.480	1.65
Total nitrogen (mg/l)	6.66	8.2	10.72
Orthophosphate (mg/l)	0.440	1.210	0.470
Total phosphorous (mg/l)	1.126	1.104	0.639
BOD (mg/l)	33.78	17.08	13.20
Potassium (mg/l)	1.27	0.66	0.05
Sodium(mg/l)	51.20	16.74	18.90
Ammonia (mg/l)	0.08	0.02	0.060
Net primary productivity (gm.C.m^2/hr)	0.49	0.89	0.65
Gross primary productivity (gm.C.m^2/hr)	0.18	0.33	0.26

Annex 11: Physicochemical parameter in Winter season

Parameters	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Mean**
Color	green	green	green	green	green	green
pH	7.39	7.13	6.91	6.92	7.5	7.17
Temperature(^{o}C)	17.39	18	17.5	16.5	17	17.3
Conductivity (µs/cm)	171	173	243	117	125	165.8
Transparency (m)	0.8	0.7	0.75	-	0.8	0.77
DO (mg/l)	8.080 l	8.860	8.486	7.486	8.081	8.19
Carbon dioxide (mg/l)	41.8	35.2	37.4	37.4	37.4	33
Ca-hardness (mg/l)	5.4	6.2	5.2	5.4	4.9	5.32
Mg-hardness(mg/l)	5.6	7.2	4.6	4.4	5.6	5.32
Total hardness(mg/l)	11	13.4	9.8	9.89	9.89	10.0
Chlorine(mg/l)	29.82	28.4	31.24	32.6	32.66	30.96
Alkalinity(mg/l)	135	140	130	150	140	139
TDS (mg/l)	800	600	800	420	415	607
TSS (mg/l)	400	200	800	800	600	560
TS (mg/l)	1200	800	1600	1220	105	1167
Nitrate (mg/l)	0.554	0.465	0.270	0.543	0.631	0.480
Orthophosphate (mg/l)	0.568	1. 388	0.71	0.606	0.732	0.8
TP (mg/l)	1.02	1.82	0.93	0.762	0.99	1.104
TN (mg/l)	5.3	4.7	3.2	4.02	3.7	4.18
BOD (mg/l)	16.4	18.27	17.3	16.7 2	16.73	17.08
K (mg/l)	0.66	0.66	0.65	0.65	0.66	0.66
Na (mg/l)	18	13.5	16.9	17.4	17.9	16.74
Ammonia(mg/l)	0.021	0.002	0.025	0.026	0.005	0.02
NPP(gm.C.m^{2}/hr)	0.83	0.90	0.87	0.93	0.94	0.89
GPP(gm.C.m^{2}/hr)	0.31	0.32	0.33	0.33	0.34	0.33

Annex 12: Physiological parameter in Monsoon season

Parameters	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Mean**
Color	Green	Green	GREEN	Green	Green	Green
pH	7.2	7.2	7	8	6.6	7.2
Temperature (^{o}C)	30	28	29.5	28	29	28.50
Conductivity (µs/cm)	302.5	317	400	223	324	313.3
Transparency (m)	-	-	-	-	-	-
DO (mg/lt)	3.42	4.08	3.10	2.95	4.35	3.58
Carbon dioxide (mg/lt)	12.8	9.6	7.2	5.2	7.6	8.48
Ca-hardness (mg/lt)	66	38	46	40	54	48. 8
Mg-hardness (mg/lt)	24	42	89	65	36	51.20
Total hardness (mg/lt)	90	80	135	105	90	100
Chlorine (mg/lt)	27.4	31.2	28.8	32.2	27.5	29.42
Alkalinity (mg/lt)	127	114	113	115	113	116.4
TDS (mg/lt)	900	705	543	510	500	625.60
TSS (mg/lt)	500	315	914	913	810	690.40
TS (mg/lt)	1400	1030	1427	1423	1310	1328
Nitrate (mg/lt)	0.982	0.577	0.0.84	0.97	0.77	0.8278
Orthophosphate (mg/lt)	0.581	0.732	0.84	0.73	0.472	0.671
BOD (mg/lt)	33.33	34	35.6	32.4	33.6	33.78
Potassium (mg/lt)	0.42	0.52	0.62	0.6	0.4	0.5
Sodium (mg/lt)	56	53	48	50	49	51.20
Amonia (mg/lt)	0.095	0.085	0.073	0.074	0.073	0.08
NPP (gm.C.m^2/hr)	1.24	1.23	1.3	1.05	1.52	1.27
GPP(gm.C.m^2/hr)	0.21	0.19	0.20	0. 15	0.17	0.18
TN(mg/lt)	6.53	6.34	6.32	6.88	7.34	6.66
TP(mg/lt)	1.3	1.02	0.99	1.2	1.12	1.126

Annex 13: Sitewise water quality data of Summer Season

Parameters	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Mean**
color	Green	Green	Green	Green	Green	Green
pH	7.9	6.7	6.4	8.2	7.2	7.3
Temperature (^{0}C)	29.5	28	29.5	28	29	28.50
Conductivity (µs/cm)	114	123	94	220	213	152.80
Transparency (m)	-	-	-	-	-	-
DO (mg/lt)	5.42	6.3	4.98	4.74	4.83	5.25
Carbon dioxide (mg/lt)	16.3	12.4	13.2	11.9	10.2	12.80
Ca-hardness (mg/lt)	45	35.9	82	63	66	58.38
Mg-hardness (mg/lt)	35	39.9	20	32	30	27.10
Total hardness (mg/lt)	80	75.8	102	95	96	89.84
Chlorine (mg/lt)	29.4	33.2	30.8	34.2	29.5	31.42
Alkalinity (mg/lt)	127	114	123	105	111	116
TDS (mg/lt)	435	413	415	502	402	443.4
TSS (mg/lt)	215	223	250	207	293	237.6
TS (mg/lt)	650	636	665	709	695	671
Nitrate (mg/lt)	1.982	1.52	1.44	1.73	1.57	1.65
Orthophosphate(mg/lt)	0.3	0.342	0.375	0.29	0.245	0.3104
BOD(mg/lt)	10.12	12.6	13.5	15.5	14.5	13.20
Potassium(mg/lt)	0.042	0.052	0.062	0.060	0.040	0.050
Sodium(mg/lt)	19	20	18	18.5	19	18.90
Amonia(mg/lt)	0.062	0.071	0.065	0.061	0.061	0.060
NPP (gm.C.m^2/hr)	0.76	0.59	0.58	0.63	0.68	0.65
GPP (gm.C.m^2/hr)	0.27	0.28	0.25	0.26	0.23	0.26
TN(mg/lt)	9.57	10.52	11.3	10.7	11.5	10.72
TP	0.952	0.666	0.495	1.325	0.765	0.8326

Annex 14: Ecological study of floating plants (Average of 3 plots: Free floating and floating leaved: estimation for diversity, density, frequency, coverage and dominance)

Name of the species	Total coverage	Average coverage	Relative coverage	Frequency	Density (Pl/m^2)	Ecological Dominance	Diversity
Ludwigia adscendens	40.5	6.75	8.01	75	105	0.007	0.04
Trapa quadrispinosa	92.5	15.41	8.29	100	63	0.037	0.09
Pistia straiotes	118	19.66	21.33	100	97.8	0.0239	0.14
Nelumbo nucifera	118	0.5	3.24	75	24	0.0009	0.03
Nymphea nouchali	118	19.66	21.33	100	21.6	0.028	0.13
Potamogaton nodusus	0.3	0.5	0.593	50	93.9	0.023	0.11
Lemna minor	67.5	11.25	13.35	75	95	0.024	0.14
Wolfia globosa	0.3	0.5	0.5934	50	85.4	0.019	0.10
Hydrilla verticillata	45	7.5	8.902	25	73	0.017	0.08
Total sum					521.7		0.86

Species

Annex 15: Population census of Mugger crocodile

SN	Date and time of observation	No. of Mugger Found	Nature of day	Estimated Population
1	February 10	-	Cloudy and Foggy	2-4
2	" 11	-	Cloudy and Foggy	
3	" 12	-	Cloudy and Foggy	
4	" 13	-	Cloudy and Foggy	
5	" 14	-	Cloudy and Foggy	
6	" 15	-	Cloudy and Foggy	
7	" 16	-	Cloudy and Foggy	
8	" 18	4	Sunny day	
9	" 19	4	Sunny day	
10	" 20	4	Sunny day	
11	" 23	-	Cloudy and Foggy	
12	" 24	-	Cloudy and Foggy	
13	" 25	-	Cloudy and Foggy	
14	" 26	4	Sunny day	
15	" 27	4	Sunny day	

Annex 16: Vegetation analysis of lake

Vegetation analysis: Site 1

S.N	Name of Species	No. of Plants	Density (pl/ha)	ni/N	(ni/N)2	Species Diversity
1	*Shorea robusta*	12	133.33	0.2608	0.0680	0.152
2	*Dalbergia sisso*	3	33.33	0.0652	0.00425	0.0773
3	*Mallotus Phillipensis*	3	33.33	0.0652	0.00425	0.0773
4	*Sclercheia oleosa*	3	33.33	0.0652	0.0425	0.0773
5	*Syzygium cumini*	5	55.55	0.1086	0.0117	0.1047
6	*Termanilia nudifera*	2	22.22	0.043	0.00186	0.0587
7	*Aporusa octandra*	1	11.11	0.0217	0.00047	0.360
8	*Alstoria scholarasis*	1	11.11	0.0217	0.00047	0.360
9	*Cleistocalyx operculata*	2	22.22	0.1043	0.00186	0.0587
10	*Cassia fistula*	3	33.33	0.652	0.0425	0.0773
11	*Garuga pinnata*	3	33.33	0.652	0.0425	0.773
12	*Ficus racemosa*	2	22.22	0.652	0.00186	0.0587
13	*Listia monopetala*	2	22.22	0.0430	0.00186	0.0587
14	*Kukurdiano*local name*	4	44.44	0.0430	0.00755	0.0921
	Total value	46	511.06	0.0869		0.99

Vegetation analysis of lake: Site 2

S.N	Name of Species	No. of Plant$	Density (pl/ha)	ni/N	(ni/N)2	Species diversity
1	Adina cardiflolia	4	44.44	0.1	0.01	0.1
2	Carea arborea	1	11.11	0.025	0.000625	0.04
3	*Shorea robusta*	7	77.77	0.175	0.03062	0.132
4	*Termanlia alata*	2	22.22	0.05	0.0025	0.065
5	*Terminalia belleracia*	1	11.11	0.025	0.00625	0.04
6	*Phoenix aculis*	2	22.22	0.05	0.0025	0.065
7	*Cassia fistula*	2	22.22	0.05	0.0025	0.065
8	*Listia Monopotela*	3	33.33	0.075	0.000562	0.0843
9	*Anogeissum latifolia*	2	22.22	0.05	0.0025	0.065
10	*Bahunia verigata*	3	33.33	0.075	0.00056	0.0843
11	*Prunus ceranoides*	3	33.33	0.075	0.00056	0.0843
12	*Dalbergia sisso*	2	22.22	0.05	0.0025	0.065
13	*MallotusPhillipensis*	2	22.22	0.05	0.0025	0.065
14	*Bombax cieba*	1	11.11	0.025	0.00625	0.04
15	*Engehadia spicata*	2	22.22	0.05	0.0025	0.065
16	*Garaga pinnata*	2	22.22	0.05	0.0025	0.65
17	*Toona ciliata*	1	11.11	0.025	0.00625	0.04
	Total value	40	444.4			

Vegetation analysis of lake: Site 3

S.N	Name of Species	No. of Plants	Density (pl/ha)	ni/N	(ni/N)2	Species diversity
1	*Cleistocalyx operculata*	1	11.11	0.0238	0.00056	0.0386
2	*Syzygium cumini*	7	77.77	0.166	0.02755	0.00584
3	*Terminalia alata*	2	22.22	0.047	0.0022	0.0624
4	*Aporusa octandra*	1	11.11	0.0238	0.000565	0.0386
5	*Shorea robusta*	8	88.88	0.1904	0.0108	0.1817
6	*Adina cardiflolia*	2	22.22	0.047	0.0022	0.06841
7	*Engchardianspicata*	1	11.11	0.0238	0.00056	0.0386
8	*Acccia catechu*	2	22.22	0.047	0.0022	0.0684
9	*Toona ciliate*	2	22.22	0.047	0.0022	0.0684
10	*Dalbergia sissoo*	2	22.22	0.047	0.0022	0.0684
11	*Phoenix acculis*	1	11.11	0.0238	0.00056	0.0386
12	*Albizia nepalensis*	4	44.44	0.0952	0.00906	0.0972
13	*Prunus ceranoids*	2	22.22	0.0476	0.0022	0.06840
14	*Termanallia belleracia*	3	33.33	0.0714	0.00509	0.104
15	*Aspera octandra*	4	44.44	0.0952	0.00906	0.009
	Total value	42	471.44			0.889

Annex 17: Marsh vegetation analysis

Plot 1: Marsh vegetation analysis

Name of plants	D(pl/m2)	D(pl/ha)	RD	F	RF	C(Avg)	RC
Phragmites karka	50	500000	30.41	100	11.11	10	19.49
Sachrum spontanium	19.5	195000	20.17	100	11.11	9.5	17.80
Imperata arundinacia	9.5	95000	9.83	100	11.11	9.10	17.70
Oryza rupipagon	4.3	43000	4.49	75	8.33	2.25	4.37
Cyperus diffusus	3.72	37200	3.84	75	8.33	1.50	2.91
Erianthus ravaennae	6.62	66200	6.84	100	11.11	8.5	16.54
Arundo donax	8.41	84100	8.27	100	11.11	2.75	5.35
Themeda arundinacia	2.50	25000	2.59	50	5.56	2.25	4.38
Imperata species	4.60	46000	4.75	75	8.34	3.05	5.93
Aphuda mutica	3.80	38000	3.93	25	2.79	0.25	0.48
Polygonum barbatum	0.25	2500	0.26	50	5.56	1.25	2.43
Perscaria hydropyper	4.02	40200	4.16	50	5.56	1.25	2.43
Total value	96.67					51.2	

Plot 2: Marsh vegetation analysis

SN	Name of plants	D	RD	F	RF	C(Avg)	RC
1	*Phragmites karka*	42	60.62	100	17.39	20.2	37.58
2	*Sachhrum spontanium*	7.39	10.67	100	17.39	9.8	16.78
3	*Erianthus ravennae*	6.54	9.44	100	17.39	7.6	13.08
4	*Themeda arundinacea*	2.52	3.63	75	13.04	8.2	14.04
5	*Cyperus rotundus*	2.64	3.81	50	8.69	6.3	10.78
6	*Acorus calamus*	0.07	0.10	50	8.69	0.5	0.85
7	*Alternanthera Philoxeroids*	4.07	5.90	50	8.69	0.5	0.85
8	*Diplazium esculentum*	4.03	5.82	50	8.69	5.3	9.07
	Total value	69.28				38.4	

Annex 18: Ecological data for climbers and vines

Site 1

Name of the plants	**No. of plants**	**Density (Pl/ha)**	**ni/N**	**Dominance (ni/N)2**	**Diversity (ni/Nlogni/N)**	**Diversity Index**
Bahunia Vahlii	10	111.11	0.45	0.25	0.16	0.46
Dioscorea bulbifera	*7*	77.77	0.32	0.10	0.16	
Spatholobus parviflorus	*5*	55.55	0.23	0.05	0.15	

Site 2

Name of the plants	**No of plants**	**Density (Pl/ha)**	**ni/N**	**Dominance (ni/N)2**	**Diversity (ni/Nlogni/N)**	**Diversity Index**
Bahunia Vahlii	14	155	0.45	0.25	0.16	0.47
Dioscorea bulbifera	15	166	0.32	0.10	0.16	
Spatholobus parviflorus	1	122.22	0.23	0.05	0.15	

Annex 19: Rainfall and Temperature data of Mahendranagar

{Latitude (deg/min): 2902, Longitude (deg/min): 8013, Elevation (m): 0176}

Rainfall (mm) for Mahendranagar

Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1998	4.2	20.5	59.8	18.6	60.0	252.7	681.4	906.8	288.2	151.8	2.0	0.0
1999	31.6	0.0	DNA	0.0	92.6	287.1	340.4	DNA	DNA	DNA	DNA	DNA
2000	DNA	DNA	DNA	DNA	DNA	466.9	428.0	1046.9	400.8	0.0	0.0	0.0
2001	20.2	18.7	1.6	4.6	75.0	570.4	445.8	217.8	39.8	13.5	0.0	0.0
2002	43.8	67.5	0.0	44.4	12.0	207.0	278.4	788.0	520.5	24.8	15.6	3.5
2003	65.2	76.6	12.9	5.8	17.9	240.1	DNA	DNA	DNA	0.0	0.0	0.0
2004	DNA	DNA	DNA	DNA	DNA	235.0	178.9	93.6	299.7	106.9	0.0	0.0
2005	72.4	59.3	59.0	0.0	16.2	122.9	553.4	317.6	456.4	18.6	0.0	3.7
2006	1.0	0.0	13.5	1.6	148.3	167.3	426.5	214.6	76.5	0.0	0.0	6.2
2007	2.0	91.1	70.2	14.5	165.4	332.1	436.5	711.9	385.8	DNA	DNA	DNA

Temperature data of Mahendranagar

Year	Temp	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	Max	17.9	23.9	26.8	34.3	37.3	37.8	33.2	32.3	32.8	31.5	28.6	23.6
	Min	6.8	9.9	14.0	21.6	26.0	28.1	25.8	DNA	DNA	DNA	DNA	7.7
1999	Max	19.5	26.0	31.7	37.9	36.6	35.3	32.8	33.1	32.0	30.5	28.3	24.3
	Min	7.9	9.1	11.0	16.3	23.2	24.2	25.6	25.2	24.3	20.8	12.1	8.7
2000	Max	19.6	22.4	29.4	35.9	35.3	32.7	32.9	32.1	32.2	31.2	27.8	23.9
	Min	7.7	7.7	11.3	17.2	24.0	24.7	25.8	25.1	23.3	18.4	13.9	7.7
2001	Max	20.0	25.6	30.4	36.1	35.9	33.9	34.0	34.0	34.6	33.3	26.1	22.9
	Min	6.7	7.6	11.4	17.4	23.2	24.3	25.4	25.4	23.3	20.0	10.6	8.4
2002	Max	22.2	25.1	32.2	35.2	36.1	35.9	34.4	32.8	30.8	31.2	27.6	22.3
	Min	6.1	9.0	14.4	18.6	24.5	25.5	26.5	25.3	22.8	18.5	12.4	9.3
2003	Max	15.6	23.6	28.7	36.3	37.5	35.5	31.9	DNA	32.8	31.3	27.5	22.4
	Min	7.7	9.6	13.3	18.0	21.8	24.7	25.6	DNA	21.2	18.5	12.4	9.3
2004	Max	15.6	24.8	33.0	35.7	36.9	34.2	33.9	34.6	32.5	30.0	26.6	22.9
	Min	7.6	9.7	13.4	19.2	22.8	24.6	25.0	25.7	24.2	17.6	11.6	8.9
2005	Max	20.6	23.8	30.3	35.9	37.6	39.9	33.5	34.1	33.6	30.6	27.2	23.8
	Min	8.0	10.1	13.5	16.9	21.4	24.1	25.1	24.5	24.0	19.6	14.5	6.9
2006	Max	22.7	26.3	31.7	36.0	35.6	36.1	33.4	33.5	32.7	31.6	26.9	23.1
	Min	6.8	11.7	12.3	18.0	22.8	25.9	25.7	25.8	24.0	19.5	12.8	8.8
2007	Max	20.9	23.5	28.3	35.1	35.0	37.7	32.6	32.5	32.9	DNA	DNA	DNA
	Min	5.2	9.4	12.6	17.3	20.9	25.8	25.8	25.5	24.9	DNA	DNA	DNA