Chapter 1

Introduction
1. **Introduction**

1.1. **Background of the study**

River is simply defined as a dynamic body of water, which flows from higher ground elevation, like hills and mountains, towards lower levels, like the sea. But, rivers are not so simple linear features delimited by the bed and banks of the main channel, and dominated by downstream transfer of water. Currently, rivers are explained as dynamic, three dimensional systems dependent upon longitudinal, lateral and vertical transfers of material, energy and biota. Their physical, chemical and biological characteristics depend upon the interactions of hydrological, geomorphological and biological processes over a range of time scales (Calow and Petts, 1992; Petts and Amoros, 1996). The structure and function of river ecosystem are determined by the interactions between five elements, physical structure, water quality and quantity, condition of riparian zone and floodplain, and the diversity and population of plants and animals living in streams (Rutherford et al., 2000). Any change in one of these elements can have significant impact upon other parts of the system.

Only a miniscule proportion (0.006%) of the world’s freshwater is present in streams and rivers at any one time (Shiklomanov, 1993), but this statistic belies the significance of lotic system in human kind and the biosphere. River laid the foundation for human civilization more than ten thousand years ago when human started cultivating crops on the flood plains, and later expanded it away from the rivers by carrying river water through an extensive network of canals. This initial step of water withdrawal from rivers gradually led to elaborate river regulation involving storage and transfer, and channelization of flow by constructing embankments. These activities picked up pace only about a century ago. Soon, the impacts of river regulation became evident in the decline of biodiversity especially fisheries and the concern against dams was expressed as early as 1940s (Gopal, 2003). Running water provide a plethora of utilities for human kind including source of water for domestic, industrial and agricultural use, waste disposal, routes for navigation, and locations for the pursuit of leisure activities. Thus, from time immemorial, rivers are meeting the multifarious demands of society at the expense of its own health. Many types of river ecosystem have been lost and population of many riverine species have become highly fragmented due to human intervention (Dynesius and Nilsson, 1994; Bunn and Arthington, 2002). The human activities damaging river system includes; i) supra catchment effects such
as inter basin transfer of water, acid deposition, climate change, ii) catchment land use change, iii) river corridor ‘engineering’ and, iv) in stream impacts (Arthington and Welcomme, 1995; Junk, 2002). Wetzel (2001) explained that the impending environmental problem are not only the result of population growth but the result also from technological growth, both directly in the sense of increased per capita production and consumption and indirectly in that technology has furthered the growth of population and urbanization. This is termed as demotechnic concept of growth and is currently most evident in tropical countries, where most global biodiversity resides and where rapidly expanding human population and increasing exploitation of natural resources can exert great pressure on river ecosystems (Farley and Daly, 2004; Agostinho et al., 2005; Schindler, 2007).

India is a tropical country with about 29,000 kilometres of river systems and comprises the Himalayan rivers Indus, Ganges, and Brahmaputra traversing thousands of kilometres in upland forming a very rich and dynamic resource of high altitude fisheries, where cold water fishes abound (Kamal, 2006). The eastern Himalaya drained by the Brahmaputra has greater diversity of cold water fish than western Himalayan drainage (Sehgal, 1999). Eastern Himalaya is considered as one of the hotspots of freshwater biodiversity in the world (Kottelat and Whitten, 1996). Over the years uncontrolled and often indiscriminate fishing in the largely unmanaged Himalayan rivers and streams has resulted in a sharp decline in catches of the important subsistence and sports fish (Sehgal, 1999). The increasing use of river water for irrigation, hydropower production, municipal and industrial purposes, and the inputs of pollutants, have all affected fish stocks. But there is hardly any information on the ecology and fisheries of rivers of the eastern Himalayas (FAO, 2002). Darjeeling Himalaya, being an integral of the eastern Himalaya, is regarded as one of the two biodiversity hot spots of India.

The hilly and Himalayan part of the northernmost Darjeeling district of Indian state of West Bengal is popularly known as ‘Darjeeling Himalaya”. The district lies between latitude 27°13′05″ and 26°17′10″ North and between longitude 88°53′00″ and 87°59′30″ East and fosters many perennial rivers and streams which flow through deep gorges. The district has 3398 km of riverine resources, which belongs to the Himalayan river system (Ghoshal, 2002). The rivers of this group are glacier-fed, spring-fed, and rain-fed, originating from the Himalayas to traverse great alluvial Indo-Gangetic plains. Some rivers of this region belong to Ganga river system (for example, Mahananda and Balason) others like Teesta and Jaldhaka belong to the Brahmaputra river system. The glacier-fed river Teesta is the largest river in
this region and the river flows through deep mountainous gorge known as Sevoke-Gola pass. The river below the confluence with the Great Rangit flows entirely through the Darjeeling district for about 29 km before it debouches into the flood plains of North Bengal. Thus, it forms a kind of ecotone through which migratory fishes move upland and to the down. The altitude varies from about 300m above msl at Melli Bazar to about 145 m above msl near Sevoke. In this stretch, the river Teesta receives a number of tributaries on both of its bank, among which the spring fed river Relli is an important left bank tributary. Darjeeling Himalaya with rich biodiversity and high level of endemism is under immediate threat of species extinction and habitat destruction mainly due to tremendous pressure from demotechnic growth and also because of natural environmental changes. Lotic waters are perhaps the most impacted ecosystem of the region.

Records revealed that neotectonic activity coupled with high level of flush flood caused massive shifting of Teesta River from Ganga river system to Brahmaputra in the year 1787 and floods during subsequent years caused bank failures, meandering, widening and elevating the river bed (Anon, 2001). In September 1899, the entire well stocked big-fishes of the Teesta, the Great Rangit, Little Rangit and Rammam were either killed or carried off to sea due to devastating cyclone (Malley, 1907). In the year 1968, unprecedented cloud burst caused havoc land slides into the river, the Teesta and its tributaries ran wild. Bridges were swept away, mud and debris poured into the rivers and streams. Fishes were swept away and died in thousands. Rivers and streams became fishless (Sen and Biswas, 2006). Reports are also coming that glaciers are receding in Sikkim Himalaya. Zemu–glacier in Sikkim retreated 440m during the period from 1909 to 1965 (Joshi, 1990). Glacier retreat and global warming is affecting rainfall pattern, temperature regime, and wild life distribution.

Two hydro-electric projects namely Teesta Low Dam Project-III and IV (TLDP-III and IV) are being constructed on river Teesta in this region by National Hydro Power Corporation (NHPC). Six other dams are in progress on the river in Sikkim and further downstream a mighty barrage without fish ladder at Gajoldoba in Jalpaiguri district already exists. A group of environmentalist are of the opinion that dancing and roaring Teesta will be silenced and rich biodiversity will be lost if the dam building on the Teesta is completed. The Teesta and its tributaries are also impacted because of high population growth, construction of highways, roads, bridges, destruction of riparian vegetation and watershed forest cover, denudation causing high siltation, boulders and sand-lifting, landslides, rampant fishing,
disposal of untreated sewages, indiscriminate use of pesticides and fertilizers in agricultural practices, altered land use pattern and so on.

Rivers are not simply dynamic body of water or vector of water resources. They constitute living environments that harbour highly varied organisms (for example, Phytoplankton, Periphyton, Zooplankton, Benthos, fishes, and so on.) in great quantity and quality and linked among themselves by nutritional relationships. The basic structure of riverine food chain is Phytoplankton – Zooplankton – Fishes. According to Faurie et al. (2001), the biological structure maintains its quality and productivity to the extent that it has a high degree of diversity (large number of species in complementary roles) and density (large number of individuals ensuring assimilation and transformation of inputs). Rivers like Teesta within its drainage basin is central to surface water ecosystems. The hydrological, chemical, and biological characteristics of river reflect the climate, geology, disturbances and vegetational cover of the drainage basin (Wetzel, 2001). The ultimate aim of ecology is to study the interaction of organisms with their environment and the other organisms living in it (Wilson, 1992; Krebs, 2001). The interactions actually determine the distribution and abundance of organisms (Krebs, 1985).

Phytoplankton is the primary producer of organic matter in riverine ecosystem and constitutes the first trophic level in the pelagic food-web and through the process of photosynthesis provides food and oxygen to other organisms and can be used as indicator of the trophic phase of the water body (Verma and Datta Munshi, 1987; Bohra and Kumar, 1999). The quality and quantity of phytoplankton population in a biotope is altered by any change in the prevailing environmental conditions and biotic variables. The zooplankton forms a vital link in the food-chain between the phytoplankton and the higher trophic levels in riverine ecosystem. Its diversity is a good indicator of the health of an aquatic ecosystem (Cozar et al., 2003). Physico-chemical variables such as temperature, pH and dissolved oxygen also regulate the density and diversity of zooplankton (Berjins and Pejler, 1987, 1989). River fish which provide a major source of food and recreation is also useful for characterizing environmental conditions in streams and rivers. A stream ecosystem has to have a healthy and diverse fish community (Cowx, 1998).

1.2. Rationale of the study

The mountain fluvial ecosystem is unique as well as distinct in all aspect, especially in the tropics. Stretch of largest glacier-fed river Teesta in the Darjeeling Himalaya forms a
link between Himalayan mountainous part and flood plains of North Bengal. Thus, it portrays a kind of ecotone, an excellent riverine ecosystem in the eastern Himalayan Hotspot. The region with rich biodiversity and high level of endemism is under immediate threat of species extinction and habitat destruction mainly due to tremendous pressure from demotechnic growth and also because of natural environmental changes. Its left hand tributary Relli represents typical ecosystem of a Himalayan spring-fed hill-stream. Though lying in the subtropical latitudes, both of them are functioning under the influence of tropical seasonality. Rivers within their drainage basins are central to surface water ecosystems. The hydrological, chemical, and biological characteristics of a river reflect the climate, geology, and vegetational cover of the drainage basin. Diversity of basic food chain that is, phytoplankton, zooplankton and ichthyofauna is a good indicator of the health of an aquatic ecosystem. The diversity of plankton and fish enable a synthetic and complete assessment of the quality of the water and aquatic environment by means of diversity indices. The diversity of species found in the environment is the surest guide to the fight against water pollution (Faurie et al., 2001). Biodiversity is thus, one of the potential and essential characteristics of life for proper functioning of fluvial ecosystem and a means of coping natural and anthropogenic environmental changes. Thus, diversity of plankton and fish fauna in relation to the physico-chemical water quality will be good indicator of the health of the river and its drainage basin. It will also unveil the mystery of regulatory mechanism of diversity dynamics prior to loss of fine tune of riverine ecosystem due to anthropogenic activity. Scientific understanding of diversity of phytoplankton, zooplankton and ichthyofauna in relation to limnochemistry of river Teesta and Relli in the Darjeeling Himalaya will help in generation of constructive alternatives to meet the challenges of sustainable equitable development and utilization of the Teesta river system, especially for future capture fishery.
1.3. Aims and Objectives

The nucleus of the present study was therefore, to compare population density, diversity index, evenness, richness and dominance of phytoplankton, zooplankton and ichthyofauna in relation to physico-chemical water quality of the glacier-fed river Teesta and the spring-fed hill-stream Relli in the Darjeeling Himalaya. The present work evaluates the hypothesis that tropical seasonality of this sub-tropical region affects the physico-chemical water quality of glacier-fed river and spring-fed hill-stream in different styles. This as a far-reaching consequence alters the density and diversity of phytoplankton, zooplankton and ichthyofauna in a predictable manner.

Therefore, with the above background, the present study entitled “Diversity of plankton and ichthyofauna in relation to limnochemistry of river Teesta and Relli in the Darjeeling Himalaya” has been executed for a period of two years (March 2007 to February 2009) and consisted of the following objectives.

I. To study some physico-chemical parameters of both the rivers and make a comparative account.
II. To determine the meso- and macroplankton diversity, evenness, and species richness in the two different types of river.
III. To study the ichthyofaunal diversity of both the rivers.
IV. To determine the relationship between physico-chemical factors and biota (plankton and fish) of both the rivers.
V. To suggest some suitable steps for better management of the water bodies.