1. INTRODUCTION

Rivers are the most important freshwater resource for humans. Social, economic and political development has, in the past, been largely related to the availability and distribution of freshwater riverine systems (Chapman, 1996). River consist of a complex mixture of distinctive habitats, which make it among the most productive and valuable ecosystem on earth (Das and Sharma, 2012). River with its tributaries is a unique type of ecosystem which generally covers different types of climatic zones, landscapes and biogeographical regions. River is the natural drainage system of the land mass of the earth which move continuously. Near the source, the river is small, straight and swift while in downstream the velocity of water decreases and meandering of river begins in the plains. As the velocity of water current gets reduced, the load it carries is deposited as silt, sand and mud (Datta Munshi and Datta Munshi, 1995).

Several small rivers emerging from the major rivers or those which originates from other sources are also quite important from the point of view of national economy and as habitat of different species of fishes. Many such rivers have been subjected to unscrupulous abuse from human activities which contributed to the loss of water flow, or bed rising, or bank erosion, or even diversification of the course of river (Das, 1999).

1.1 Indian River Ecology

In India there are five major river systems, namely the Ganga, the Brahmaputra and the Indus river system in north, together with the Peninsular East coast and West Coast river systems in south. Rivers in India have unique hydrological regime characterized by peak flows during monsoon and lean flows either in winter (Himalayan
rivers) or in summer (Peninsular rivers) (Sheeba, 1999). The Himalayas are the source of freshwater rivers so they can be called “the cradle of major rivers” that supports the life of many ecosystems. The Himalayan Rivers receive about 20-30 % of their water from melted snow during the summer and monsoon seasons (Khanna and Matta, 2011). The Himalayan range comprises three huge watersheds of Indus, Ganga and Brahmaputra (Unni, 2003).

Indian rivers with a catchment area of 3.12 million sq. kms form a repository of biological wealth characterized by a highly diverse fish fauna. Rivers in India constitute the backbone of capture fisheries. The 113 major and minor rivers along with their principal tributaries form a biological wealth, unmatched in its qualitative and quantitative abundance. The rivers have through the ages supported a flourishing artisanal fisheries producing livelihood to millions of small-scale riparian fisherman. However, the increasing anthropogenic pressures on the rivers have adversely affected the fish production potentialities and they no longer support the rich biotic wealth (Sheeba, 1999).

Indian River ecology has been ruled by terrestrial ecologist and aquatic ecology has been confined largely to fishery biologists. Hydrobiological studies conducted in rivers by Bhimachar and David (1946) and Ganapati and Alikunhi (1950) were aimed towards evaluation of pollution and impact on fisheries aspects. Fisheries scientists who did most of the limnological studies (Unni, 1993) had poor knowledge of aquatic chemistry and ecology. Freshwater ecology and principles of river ecology have made significant progress due to efforts made during the past more than 50 years in India and the functioning of freshwater ecosystem have made significant advancement in developed countries (Unni, 2003).
Literature revealed lots of significant works on the ecology and fishery of Indian rivers in past years. Many workers have studied the physical, chemical and biological characteristics of water. Various studies have been made by Badola and Singh (1981), Dobriyal and Singh (1981), Singh et al. (1982 a), Nautiyal and Lal (1982 a and b), Dobriyal et al. (1983), Pokhriyal et al. (1983) and Bilgrami and Datta Munshi (1985) on the river Ganga; Dobriyal (1985), Sangu and Sharma (1985) made studies on river Yamuna.

Hamilton (1822) made an account of the fishes found in the river Ganga and its branches. Hora (1921) made his study on some new or rare species of fishes from Eastern Himalayas. Chacko and Ganapati (1949) made hydrobiological observations on the river Adyar. Further more, Chacko and Ganapati (1952) also studied the hydrobiology of Surli river of Madurai District. Venkateswarlu and Jayanti (1968) studied the hydrobiology of the river Sabarmati to evaluate the water quality. Motwani et al. (1962) studied the fish and fisheries of Brahmaputra River system Assam.

In Indian limnological aspects of several freshwater ecosystems have been studied by Welch (1948), David et al. (1969), George (1976), Sharma (1978), Unni (1982), Rao (1988), Belsare (1990), Khanna (1993) and Kumar (1995).

1.2 North Eastern Drainage and Rivers

The northeastern Himalayan region roughly constitutes the entire northeastern part of India, comprising the seven states, and is situated between 21° 57' N and 29° 30' N latitude and between 89° 46' E and 97° 30' E longitude. The area of this region is 255 000 km², of which about 70% are hilly; consequently the topography is undulating in most of the region. Numerous snow-fed streams and rivers form a network
throughout the region. Apart from innumerable streams and hundreds of rivers, thousands of wetlands, lakes, reservoirs, and ponds, are scattered everywhere in the region; needless to say, such diverse types of water bodies are the abodes of a large variety of ichthyofauna (Biswas and Boruah, 2000 a).

The seven Northeastern states of India, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura are blessed with diversified fish fauna, which assumes special interest due to the fact that the region is drained by two important drainages, viz., Brahmaputra-Barak and Chindwin Irrawaddy. This region has been ranked 6th among the top 25 biodiversity spots in the world. It has varied physiographic features ranging from rivers, valleys to snow capped mountains making it a favourable habitat for a variety of ichthyofauna. Despite such a rich resource potential, the region is lagging behind in its exploitation and management. In the high altitude stretches, utilization of rivers and streams is low due to biotic, abiotic and socio-economic constraints. Still a substantial part of the resources in this region remain unutilized and unavailable. A substantial part of the resource in the northeast comprises capture fisheries, the management of which requires higher skill. Little research attention has been given for development of fisheries in contrast to the other water bodies.

Riverine fisheries resources of Northeastern states comprise 19,150 km of streams and rivers. Except the Brahmaputra and Barak valleys in Assam and Imphal valley in Manipur, the Northeast mainly comprises hills and mountains, which forms 65% of its territory. The mighty Brhmaputra and Barak along with their tributaries form more than half of rivers in this region. Rivers of this region consist of both torrential and plain rivers. In Arunachal Pradesh, the entire 2,000 km of rivers are of true rheophilic
type. Assam alone has 5,550 km of rivers including all the tributaries of Brahmaputra and Barak. Manipur has two major rivers viz., the Barak and the Manipur with a combined length of 2,000 km. There are 21 rivers in the hilly state of Mizoram, which along with their tributaries run mainly comprise the tributaries of Brahmaputra. Barak and Tizu are main rivers of Nagaland; with combined length of 1,600 km. Rivers of Tripura have a total length of 1,200 km (Sinha, 1994).

A thorough knowledge of ecology and fishery of the rivers of North-East India is imperative to know the aquatic diversity of the region and their conservation. However, the literature provides only a few information regarding ecology and fishery of northeastern Himalayan Rivers. Most of the reports available are dealt with ecology of the Brahmaputra and Barak river system.


1.3 River systems of Assam

There are two major river systems in Assam namely the Brahmaputra river and the Barak River.
Brahmaputra River System:

The Brahmaputra is the principal river of Assam. In India, the basin lies in the states of Arunachal Pradesh, Assam, Nagaland, Meghalaya, Sikkim and West Bengal. Brahmaputra is a perennial river, fed by snow as well as by rain. The Brahmaputra rolls down the plain of Assam east to west for a distance of 640 km up to Bangladesh border.

The Brahmaputra drainage system in North East India is one of the largest hydrographic basins in Southeast Asia and sustains a very rich and diverse aquatic gene pool, particularly fishes and such as the region is featured among the global hotspots of freshwater fish diversity (Kottelat and Whitten, 1996). The Brahmaputra river system, the largest in the Indian sub-continent, is a virtual lifeline to the seven north-eastern States of India with an average annual discharge of 510,450 million m$^3$, it covers an area of 580,000 km$^2$. This mighty river is also the habitat for a large number of aquatic fauna. Very few studies have been made on the ecology in relation to the fisheries of the river system (Singh et al., 1988; Biswas and Michael, 1992; Yadava and Chandra, 1994; Biswas et al., 1995; Biswas and Boruah, 2000 b).

Through its course, the river receives innumerable tributaries (about 73) coming out of the northern, northeastern and the southern hill ranges. The mighty river with a well-knit network of tributaries drains an area of 56,480 Sq. Km of the state accounting for 72 per cent of its total geographical area. Most of the right bank tributaries of Brahmaputra are snow as well rain fed and are perennial. Although the left bank tributaries are mainly rain feed but perennial in nature.

It is the fourth largest river in the world in term of average water discharge at the mouth with a flow of 19,830 m$^3$s$^{-1}$. The river carries 82 per cent of its annual flow during the rainy season (May through October). The maximum discharge of the river at
Pandu (in Guwahati) on 23-08-62 was 72794 m³s⁻¹ and the minimum discharge at the same point on 20-02-68 was 1757 m³s⁻¹. The mean annual flood discharge and dry season discharge of the river at Pandu is 51156 m³s⁻¹and 4420 m³s⁻¹ respectively.

1.4 Fishery potentialities of North East India with reference to Assam

All north-eastern states have handful resources of fishes as well as other aquatic species in terms of many rivers with their tributaries, streams, rivulets, wetlands, lakes, ponds, tanks etc. Assam has vast and varied freshwater aquatic resources and it being regarded as one of the richest spot of biodiversity in India (Das and Sharma, 2012).

The considerably rich fish diversity in the NEH region is attributed to many reasons, viz., the geomorphology, consisting of hills, plateaus and valleys, resulting in the occurrence of a variety of torrential hill streams, rivers, lakes and swamp; drainage which include the Ganga-Brahmaputra, Koladyne and Chindwin-Irrawady systems. Another important factor is the tectonic setting in the Indo-Chine sub-region caused by collision of Indian, Chinese and Burmese plates, resulting in the formation of the mighty Himalayas and Indo-Burman ranges (Jena and Sarkar, 2012). Ichthyofaunistic resources of the region exhibit a combination of both torrential and plain water forms as well as cold and warm water species and occupy diverse ecological regimes in their distributional range (Sinha, 1994).

In India, there are 2,500 species of fishes; of which, 930 live in freshwater and 1,570 are marine (Kar, 2007). Out of the approximately 806 fish species inhabiting freshwater of India (Talwar and Jhingran, 1991), the North East including Assam is reported by 266 species (recorded and reported) belonging to 114 genera under 38 families and 10 orders (Sen, 2003) out of which 196 fish species occurring in North-east
have potential ornamental value (Dey et al., 2002). The survey of fish fauna of Brahmaputra in Assam reported 41 fish species of commercial importance (Jhingran, 1999). So far economic value of the fishes is considerable percentage of fish 35% are considered as food fish followed by 29% as ornamental.

Sen (1985) reported 48 species to be endemic to Assam and the neighboring states of India. Ghosh and Lipton (1982) reported 33 species to be as restricted in their distribution to this region. Endemic species recorded from these states are 12 each from Assam and Arunachal Pradesh, 7 from Manipur, 6 from Meghalaya and one each from Mizoram and Tripura (Gurumayum and Choudhury, 2009). However, the recent report (Viswanath et al., 2008) described 160 fish species as endemic to this region.

Through NBFGR’s collaborative programme, a total of 296 species of 110 genera under 35 families have been described which also reports several new species (Viswanath et al., 2008) from this region. However, previous studies from this region reported a wide variation in number of fishes ranging from 172 (Ghosh and Lipton, 1982) to 267 (Sen, 1985; Yadav and Chandra, 1994; Sinha, 1996 and Sen, 2000).

1.5 Pagladia River and present study

The Pagladia is an important tributary among the tributaries on the north bank of the Brahmaputra valley, which passes through Bhutan Hills of Himalayan range. In the course of origin of Pagladia River, the denudation of the mountains has taken place at a faster rate than their upheaval resulting in the formation of the deep gorges (found in channel), at the same time keeping its channels open. Out of the total catchment area of Brahmaputra river system, Pagladia River bears total 1820 km² catchment area, of
which 460 km\(^2\) in hills and 1,360 km\(^2\) in plains. Within the geographical area of Assam Pagladia river has 87 km\(^2\) of total watershed area (Das, 1990).

Though, there are many works were done by several workers on the fisheries of the Brahmaputra basin, but there is a dearth of information on ecology and fishery of Pagladia river. Only a single report on could be found on ecomorphology of the ichthyofauna of this tributary by Dey (1975 a). After which there is no report till date. Therefore, the present study has been carried out to investigate the ecology and fishery potential of Pagladia River, a perennial tributary of the Brhmaputra river of Assam.

1.6 Objectives of the present study

1. To investigate certain important physico-chemical parameters of water such as surface water velocity, water depth and width, temperature, transparency, pH, dissolved oxygen (DO), free carbon-dioxide (FCO\(_2\)), total alkalinity (TA), total hardness (TH), total chloride (TC).

2. To investigate sediment quality of the tributary.

3. To study biotic communities of the tributary such as fish, plankton, periphyton, macroinvertebrate, macrophyte.

4. To study the methods of fishing and fishing gears used.

5. To investigate fishery resources such as food fishes, ornamental fishes and non-piscian fishery resources with their seasonal landing and marketing.