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Geography

The River Barak is the principal river of the study area from which the Barak Valley assumes its name. The valley has a total area of 6922 sq.km. representing about 9% of the entire land area of the state of Assam. It is divided into three districts, namely Cachar, Karimganj and Hailakandi and is situated between 24°8'N and 25°8'N latitude and 92°15'E and 93°15'E longitude. The valley, drained by River Barak and its tributaries, is bounded by the North Cachar Hills district of Assam and Jaintia Hills district of Meghalaya in the north. Mizoram in the south. Manipur in the east and the state of Tripura and Sylhet district of Bangladesh in the west. The valley is bounded by the Borail hills in the north. the Bhuban hills in the east and the hills of Mizoram in the south. which in turn extend as Arakan Yoma in Myanmar.

Geology

The geological formations in Barak Valley comprise mostly rocks of the Surma Group overlying unconformably the Barail group. The Surma Group (Miocene age) consists of sedimentary rocks, chiefly sandy shale. sand stones. conglomerates and clays. The soil of the area is alluvial (Dey, 1994).
Vegetation

The natural vegetation of Barak Valley is of moist evergreen and semi-evergreen type with tree species like *Artocarpus chaplasha*, *Michaelia champaca*, *Lagerstroemia flosreginae*, *Eugenia jambolina*, *Gmelina arborea*, *Ficus* spp., *Dillenia* spp., *Cedrela toona*, *Palaquium polyanthus*, *Cynometra polyandra*, *Tetrameles nudiflora* and others. The marginal vegetation around the study sites include taxa like *Commelina benghalensis*, *Cyperus* spp., *Mimosa pudica*, *Linderina crustacea*, *Eclipta prostrata*, *Monochoria hastata*, *Enhydra fluctuans*, *Justicia gendarussa*, *Adicantum* spp., *Anchyranthis aspera*, *Spilanthes paniculata* and *Sclaginella* spp. A few sites had *Mangifera indica*, *Artocarpus heterophyllus*, *Albizia lebbeck*, *Anthecephalus cadamba*, *Areca catechu*, *Bombax ceiba*, *Cocos nucifera*, *Melia azedarach*, *Alstonia scholaris*, and *Musa* spp. (Gupta. 2000).

Climate

The Barak Valley is mostly in the high pressure zone on the north of the Tropic of Cancer. To the north of the valley is the c 1500-1900 high Shillong plateau facing the Bay of Bengal. Thus, physiography as well as location in the tropics have played an important role in the climatic condition of the valley. The climate is characterized by its extreme humidity. Its most distinguishing feature is the copious rainfall between May and September. The months of March and April witness severe storms with strong wind, thunder and hail. Temperature remains high during summer. In the present study, the year was divided into three seasons, viz., pre-monsoon (February-May), monsoon (June-September), and post-monsoon (October-January).
Temperature

The monthly variations in minimum and maximum air temperatures are shown in Figures 1.1 - 1.2. The minimum and maximum temperatures in 2003 ranged between 11.7°C (January) – 25.8°C (July) and 25.3°C (January) – 33.6°C (July); in 2004 between 12.50°C (January) – 26.52°C (August) and 25.60°C (January) – 34.52°C (August); in 2005 between 13.20°C (January) – 26.10°C (August) and 25.39°C (January) – 33.75°C (July); and in 2006 between 12.20°C (January) – 25.90°C (August) and 27.12°C (January) – 34.67°C (August), respectively.

The coldest month during 2003-2006 was January and hottest month varied between July and September.

Relative Humidity

The percent relative humidity showed some diurnal and seasonal variations, although it was generally quite high. The percent relative humidity was higher in the morning than in the afternoon. In 2003 the morning relative humidity was lowest in March (79%) and highest in May (96%); in 2004 the morning RH was lowest in February (81%) and highest in July (90.67%); in 2005 the morning RH was lowest in April (79%) and highest in August (90%); and in 2006 the morning RH was lowest in March (79%) and highest in June (92%). The afternoon RH in 2003 was lowest in March (36%) and highest in June and September (71%); in 2004 the lowest afternoon RH was in December (47%) and highest in July (86%); in 2005 the lowest afternoon RH was observed in December (49%) and highest in September (87%); and in 2006 the afternoon RH was lowest in November (51%) and highest in June (79%). respectively (Figures 1.3-1.6).
Rainfall

The monthly variations in rainfall over a period of four years (January 2003-December 2006) are shown in Figure 1.7. The rainfall in 2003 varied between 0.0mm in November to 546 mm in August; in 2004 from 0.0mm in January to 433mm in September; in 2005 from 0.0mm in Jan. November and December to 474 mm in July and in 2006 it ranged between 0.0mm in January, November and December to 688 mm in June. Thus rainfall was heavy during May to September with the lowest rainfall usually in November to January.

Land Use

Many of the characteristic physical and biological features of running waters are determined by their physical settings. Therefore we need to consider them in the context of their catchment areas.

Natural vegetation in most of the catchment areas of Barak river and its tributaries have become degraded. Riparian cover is sparse. A mosaic of landscape elements has replaced the natural vegetation. Plantations of tea, rubber, teak, *Gmelina arborea*, etc. dominate in some areas. River banks are used for agriculture particularly for growing seasonal vegetables. Area under evergreen forests and grasslands has declined. Except a few, most of the areas have been dominated by human habitations. Streams with paddy cultivation as riparian land use have been recorded to be highest. However, some streams are found to be with different riparian land use type.
The Barak River System

Since the ages, rivers throughout the world played a significant role in the development of mankind civilization. Due to easy availability of water, human settlements usually developed on or near the river banks which during the course of time became important towns and cities. Water since has been used for drinking, irrigation, bathing and other recreational purposes. Industries too developed near the river banks because of two reasons; the river water could be used for running the industries and the waste water from the factory could be dumped into river. Later, the rivers also began to receive the sewage of the townships with the spurt in population and industrial activity. This naturally put pressure on the natural regeneration capacity of the river and the threat of pollution large on them. This condition necessitated studies on river with reference to pollution and the measures to prevent and control it.

The Barak river is the second largest river of Northeastern India. The Barak river exemplifies the typical Indo-Pacific river system. It rises on the escarpment of the Barail ranges from south to Jupvo peak (10,000 feet) and flows through Manipur, Cachar and Sylhet and finally empties itself into the old bed of the Brahmaputra near Bhairab Bazar. While originating from hills bordering Nagaland and Manipur it flows in a south westerly direction through a narrow valley up to Jirighat in the Assam-Manipur border. It then turns west and emerges from the hills a few kilometers above Lakhipur. On emerging from the hills, it traverses the valley in westerly direction up to Bhanga, a few kilometers below Badarpur, where, again it bifurcates into two tributaries, the Surma and the Kushiara at Hariiikar.
The length of the river up to Lakhipur is 403 km. The border of Assam along the Kushiara 564 km and up to its outfall into the Meghna near Bhairab Bazar in Bangladesh 902 km. Longai and Singla are the important tributaries of Kushiara while Gumra is the most important tributary of Surma. As it flows down the valley, the Barak is joined in by tributaries both from the north and the south. The main right bank (northern) tributaries are Jiri, Chiri, Badri. The combined flow of Dalu and Jhatinga the Madhura, the Larang, the Hareng, the Kalainchera, Balchera and Gumra. The main left bank (southern) tributaries are Sonai and Rukni, Katakhal and Dhaleswari. All these rivers, especially the Barak which adopt a meandering path through the alluvial plains, frequently shift their courses and form ox-bow lakes.

River Barak and its tributaries constitute the main drainage system in the Barak valley region of South Assam and are also the major sources of usable water.

**Major sources of water pollution in River Barak**

Literature survey has shown that there are many reports on the water quality monitoring of different rivers of India, but least attention has been given to water quality monitoring of river Barak which is one of the most important rivers in Northeastern India. There is considerable human activity of various kinds along the course of river Barak including domestic, commercial, agricultural and industrial activities. As a result, different types of waste materials enter the river continuously altering its water quality.

In the middle Barak (primary zone in Manipur, middle zone in Barak valley and lower zone in Bangladesh) zone which constitutes about 27% of the
total basin area. there are a number of centers of domestic sewage discharge into the river. Major urban sewage (at Silchar, Badarpur and Karimganj) is directly discharged throughout the year into the river without any treatment. This problem is accentuated during the low water regime between December to March with the decline in river discharge and accumulation of sewage in the river water.

Besides sewage, between Katakhal and Badarpurghat the river receives industrial effluents from Cachar Paper Mills (HPC) at Panchgram.

The cultivation of seasonal vegetables is one of the important catchment activities in the Barak river catchment. The use of chemical fertilizers for cultivation in the catchment enhances the fertility of the river through runoff waters. Leaching of these fertilizers forms an important source of pollution in river systems. Barak Valley is a major area of cultivation and the alluvial soil is quite fertile in comparison to the upstream hilly soil. However, there are no detailed studies on nutrient input from the catchment to understand the loading of these elements and their final transport via tributaries into the mainstream of River Barak.

In Barak Valley, annual festivals and fairs are held during Durga Puja (September/October) and Baruni at a number of places. Dussehra (Vijoya Dashami) is celebrated during Durga Puja when images of Goddess Durga are immersed into the river water at a number of ‘ghats’. Baruni mela is held every year during March at Badarpurghat which attracts devotees. Such annual fairs also increase pollution load in the river.
Detailed description of the study sites

Along the river Barak from upstream to downstream five stations were selected in the mainstream and seven in the tributaries. Details of sampling sites, their location in the river, physical features of the stations are given below.

Station 1: R. Chiri

It is one of the main right Barak (northern) tributaries of river Barak and the most upstream site. The catchment has rural settlements. The river bed at this station consists of large boulders strewn with smaller stones with deposition of sand. This is one of the reference sites in this study.

Station 2: R. Barak at Kashipur

It is the main stream of Barak and the length of this river up to this station is 443 km. The substratum at this station consists mainly of coarse sand and silt with gravels and pebbles. This is a reference site in this study.

Station 3: R. Madhura

It is another right bank (northern) tributary of Barak. The sampling site is 3 km upstream from the Madhuraghat Bridge on Silchar-Kumbhirgram Airport road. Both sides of river are surrounded by suburban and rural settlements. The substratum at this station consists mainly of sand.

Station 4: R. Barak at Silchar

It is located near PHE plant at Sadarghat, Silchar town. Here, both banks of the river are surrounded by built-up urban areas. Several industrial (small scale) and sewage outlets open into the river in this area. Bathing and laundry throughout
the year form important human activity. Images of Goddess Durga are immersed at this station during Durga Puja every year. Substratum is silty.

**Station 5 : R. Ghagra**

It is about 10 km from station 4. The catchment at this station consists of National Highway 44 on one side and rural as well as suburban settlement and agro-pastoral land on the other. The substratum at this station consists of small stones with deposition of sand.

**Station 6 : R. Katakhal**

It is about 12 km from station 5. Here, the R Barak confluences with R Katakhal which flows through Hailakandi district. The catchment at this station consists of rural settlements and agro-pastoral land. The river bed here is covered with a deposition of sand and silt.

**Station 7 : R. Barak at Katakhal**

It is about 1 km from station 6. The catchment at this station consists of National Highway 44 on one side and rural settlements and agropastoral land on the other. The substratum at this station is covered with a deposition of sand and silt.

**Station 8 : R. Barak at Badarpurghat**

It is about 10 km downstream of station 7. Here, the catchment comprises the National Highway 44, a large market complex and human settlements. Badarpurghat forms an important religious place of worship. Devotees come to this place during the month of March to take part in Baruni mela and take bath and offer
Ganga puja. Throughout the year people offer coconut, rice, banana and vermilion and other things which decay and pollute the river. The river bed is covered with a deposition of sand and silt.

**Station 9 : R. Kushiara**

It is about 25 km from station 8. This site is situated at the Indo-Bangladesh border. The catchment on one side consists of bamboo collection center and Steamer Ghat of Karimganj town. This site is largely influenced by the sewage of the township besides other activities. The substratum at this station is covered with a deposition of sand and silt.

**Station 10 : R. Barak at Sonabarighat**

It is about 10 km from Silchar town and upstream of station 4. The catchment on both sides comprises large agricultural land and rural settlements. The river attains its full expansion here with much flow and at the midst of the river a sandbank is developed during winter (dry period). A ferry-ghat is present at this station. The river bed consists of deposition of sand.

**Station 11 : R. Sonai**

It is about 15 km from its confluence with R. Barak a few km downstream from station 10. The catchment at this station consists of both suburban and rural settlements and large agricultural plots. The substratum at this station consists of large boulders with deposition of silt and sand.
Station 12 : R. Rukni

It is about 10 km upstream from the confluence of R. Rukni and R. Sonai near a place called Dhalai. The catchment on both the sides comprises agro-pastoral land and rural settlements. The river bed consists of big boulders and stones with sandy substratum. This is also a reference (relatively unpolluted) site in this study.

Selection of Study Sites

The choice of the number and location of reference sites in any water quality assessment is a function of the objectives of the study. For example, examination of the effects of a point (or direct) source of pollution, such as an effluent pipe, involves choosing of sites that are at varying distances above and below the point source (and which assumes no other sources of pollution above that source). Therefore, reference and control sites must be similar in as many characteristics as possible (e.g. flow, substrate type, depth, and seasons of sampling), otherwise the conclusions of an environmental assessment can be affected by this bias.

Most biological monitoring and assessment programs world-wide use the reference condition concept for evaluating test site conditions; reference conditions are usually characterized at a similar site or suite of sites believed to be representative of pristine or unimpacted habitat (Hughes 1995).

In this study twelve sampling sites were selected that represented a range of known unimpacted to impacted reaches in the catchment. Of these, three sites were selected to represent those sites that reflected the most pristine conditions in the catchment. These are R Chiri, R. Barak at Kashipur and R Rukni (Sites 1, 2 and 12, respectively). Sampling sites used in this study were located throughout the Barak River and its tributaries. Plate 1 describes the sampling sites used in this study.
Figure 1.1. Monthly variations in Air Temperature (maximum and minimum) in the study area during 2003-2004.

Figure 1.2. Monthly variations in Air Temperature (maximum and minimum) in the study area during 2005-2006.
Figure 1.3. Monthly variations in Percentage of Relative Humidity (Morning & Afternoon) in the study area during 2003.

Figure 1.4. Monthly variations in Percentage of Relative Humidity (Morning & Afternoon) in the study area during 2004.
Figure 1.5. Monthly variations in Percentage of Relative Humidity (Morning & Afternoon) in the study area during 2005.

Figure 1.6. Monthly variations in Percentage of Relative Humidity (Morning & Afternoon) in the study area during 2006.
Figure 1.7. Monthly variations in Rainfall (mm) in the study area during 2003-2006.