

**RIVER
BHADRA**

Drainage area and Topography of Bhadra River
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Drainage area and Topography of Bhadra river

Bhadra river originates at 'Ganga moola' on the Varaha Parvata (elevation 1198 m MSL) in the Western Ghats, which are a series of mountains rising from the lower western plains of Indian subcontinent. The rich diverse flora that covers this region falls under tropical wet evergreen forest category (Champion & Seth, 1968). This region has good ground water sources and an average annual 48 million m³ of ground water level is being recharged. Environment of catchment areas of the Bhadra and Tunga rivers are well described by Kadambi (1942). The striking characteristic feature of this region is the presence of continuous warmth. This area is exposed to South-West monsoon and receives a rainfall in the range of 3000 to 7000 mm per annum.

Topography of Bhadra drainage area ranges from a very steep gradient to a winding course through emerging rocks. The underlying rocks of the Bhadra river basin are said to be precambrian archaean of Dharwar schist. This belt of rock consists of granite, limestone, dolomite, chlorite schist and thick beds of magnetite quartzite. Concentration of granite and granitic gneisses are also high. Kyanite and garnet are the important minerals found in this region. Soil of the catchment areas is red loam type. It is generally granular and porous, with high draining capacity.

River Course

Bhadra river originates with two other rivers of this region - Tunga and Netravati. Bhadra river flows eastwards initially through Mudigere taluk and then turns north-east, while Tunga river flows north-eastwards through the Sringeri taluk. As compared to these two rivers, the Netravati flows westward to Dakshina Kannada district.

Initially, the river flows through the Malnad area of Chikmagalur and Shimoga districts (Fig.1). Malnad area is characterized by dry and moist deciduous vegetation. Total length of the river is 138 km covering an elevation between 606 to

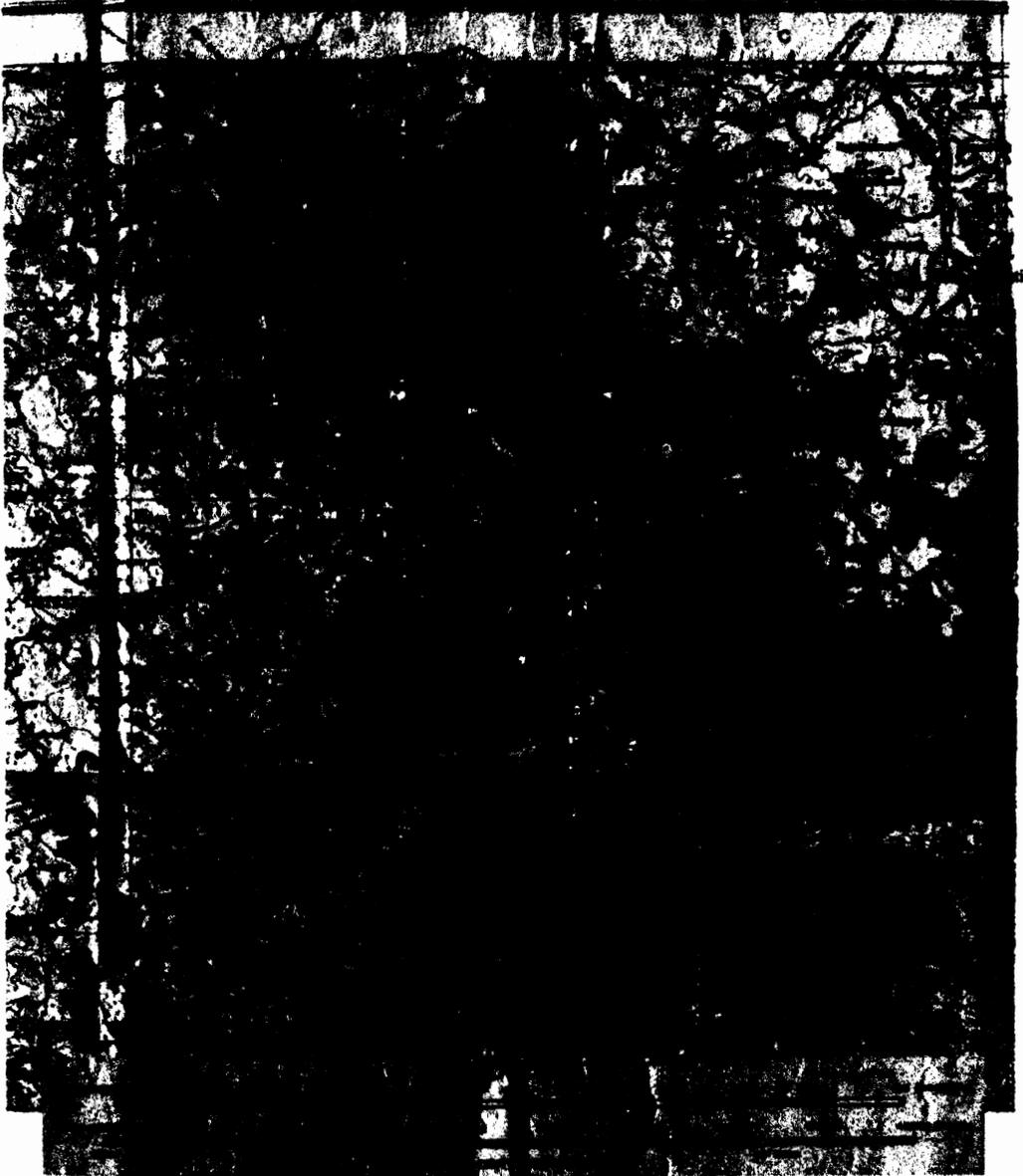


Figure 1 : Map showing Bhadra river flow in Chikkamagalur and Shimoga districts.

1679 m above MSL and sub-Montane in character. During its course in the hill terrain, it receives water from many tributaries and small perennial water course of the valley. Till the river reaches pre-Montane region, surface of river banks are covered by canopy of forest trees. This results in heavy deposition of organic material at pool regions of river within the forest and to heavy organic load in the water current. Erosion and input of material from surface layers of forest is heavy during monsoon period, which is also associated with high discharge of water in the river. Since, geographic relief of the area is steep, water course in this region is always with riffle, swirling and intermittent pools. Accordingly, river bed largely consists of granite rocks, cobbles, pebble stones and only at pool region, river bottom consists of sand.

Bhadra river has a perennial flow. In 1967 a large dam (Bhadra Dam: capacity - 71.535 TMC) was constructed at Lakkavalli (Fig. 1) across the river. Bhadra reservoir is a massive irrigational project with a wholesome variety of wildlife around it. Two canals under Bhadra Reservoir project namely, Bhadra river left bank canal of length 77 km (command area- 8300 Hectare) and Bhadra river right bank canal of length 103 km (command area -17,274 Hectare), along with two other canals of length 150 km (command area - 3200 Hectare) under Gondi project enable Shimoga and Davanagere districts as major areas under irrigation.

Water discharged from the dam initially flows close to drier area of Malnad belt. After 25 km, river flows close to Bhadravati town. The town is sloping from east to south-west. Geographical area of Bhadravati taluk is 690 sq. km, lies between latitude 13° 42' to 14° 6' North and longitude 75° 35' to 75° 52' East, at an elevation of 620 m MSL. Bhadravati taluk consists of about - 150 villages with a total population of 3,24,700 (Rural 1,75,600, urban 1,49,300). Major part of the taluk comes under semi Malnad area or also called transitional zone. The terrain is undulating or hilly and rainfall is obvious, moderate growth of vegetation is witnessed. The other part of the taluk covers maidan region, which is mainly plains,

scanty vegetation and rainfall is comparatively low. Forest area extends 1,8239 Hectare.

Bhadra river flows through Bhadravati taluk for a length of 51.5 km. Along the course, it receives about 1800 fifth order drains of total length 1008 km (Fig. 2). About 20 km from the Bhadravati town, the river joins Tunga river at Kudali, and flows as river Tungabhadra. It is the main drainage system of the Krishna river. At Bhadravati, the right bank (being lower than the left) is subjected to overflow whenever there is a moderate rise of water. Exposed sandy part of the bed is generally covered by scrubby and bushy vegetation. River stretch forms many small islands with bushy vegetation, which harbour large number of aquatic birds. There are numerous broken up canals, quiet pools and riffles fit enough to shelter a good number of fish population in the stretch of the river near Bhadravati. On the left bank of the river Bhadra near the Bhadravati town, two major public industrial units Vishveshwaraya Iron and Steel Ltd.(VISL) and Mysore Paper mill (MPM), and Sugar industries are located. As a result, for over a stretch, river water is polluted. Even though both industries have installed pollution treatment plants, they are not able to change the brown colour of the effluent due to non-availability of viable technology. Sewage wastes of the town and untreated effluent of the small industrial units are also let into the river making it non- potable. All along Bhadravati town to Kudali, large numbers of vegetable gardens are located close to the riverbank and vegetables are grown by using river water. Anthropogenic activities like washing cloth, ablution is more evident along this stretch. Daily fishing activity is also common. About 500 fishermen families are entirely dependant on the fishery resources of this stretch of the river. Along the river course, good amphibian diversity is witnessed. Many of the species are found to occur in the river during their larval stages. Crocodiles and otters are observed frequently at this stretch of river.

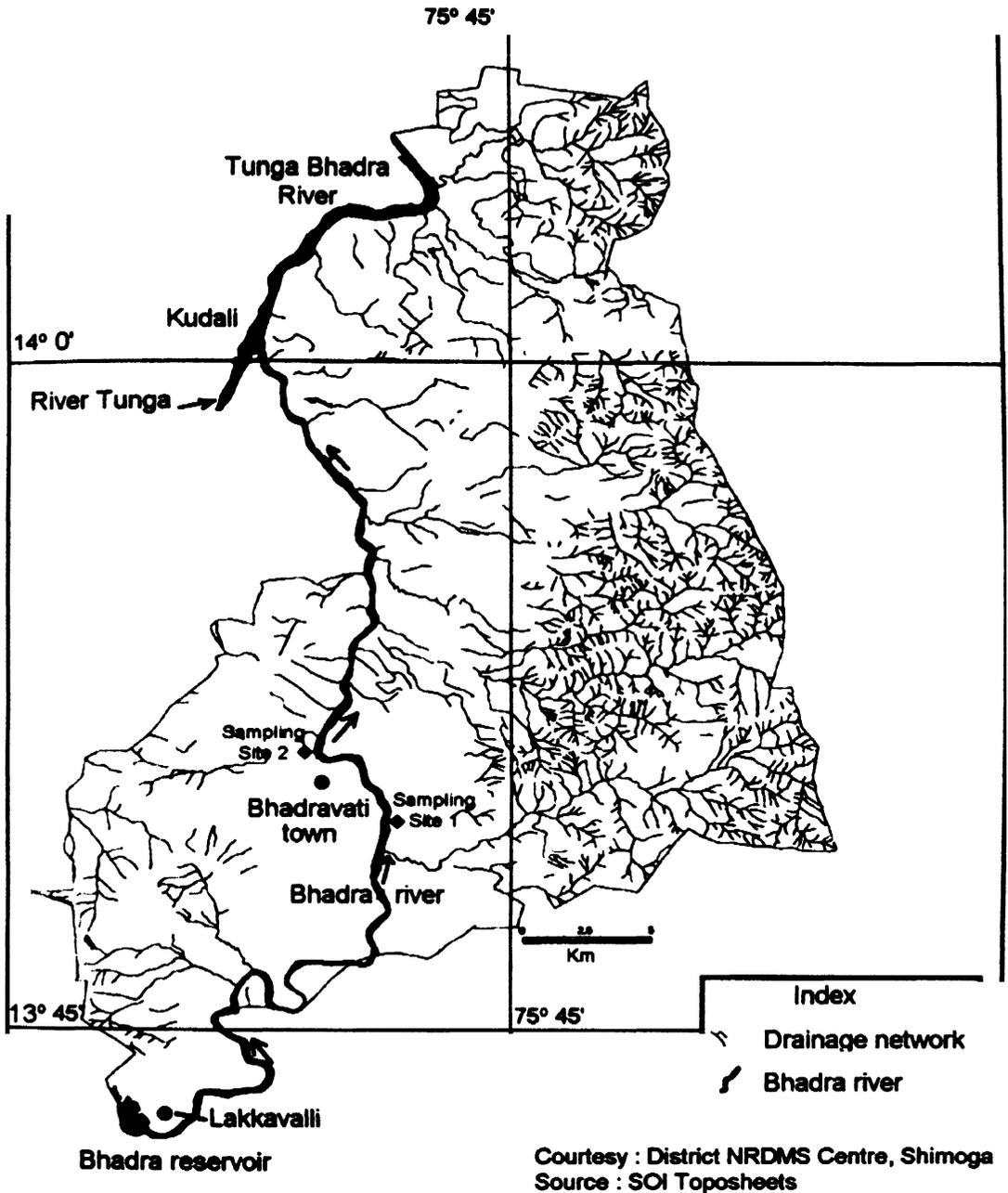


Figure 2 : Bhadra river map and their drainage network in Bhadravati taluk.

Water discharge from Bhadra reservoir

Data on water inflow and discharge through Bhadra reservoir was obtained from the Gauging station, Bhadra reservoir irrigation department located at BR project (an upstream point of the river) is presented in Table 1. Water level was found to be high from August through December. The annual mean of reservoir water level was around 47.14 m.

During the months of July and September 1999 and August 2000 the inflow of water to the reservoir remained very high (19885.6- 7803 million cubic meter). Similarly minimum inflow (87.1 and 64.9 million cubic meter) was recorded during March 1999, May and July 2000 respectively. Peak discharge of water through the reservoir was noticed in the months of August 1999 (1585.3 million cubic meter) and September 2000 (1032 million cubic meter) and October 2000 (886.8 million cubic meter). Lean discharge was noticed during December 1999 (49.6 million cubic meter) and November 2000 (43.2 million cubic meter).

Phenology

Karnataka plateau enjoys three types of climate. a) Tropical monsoon climate- covers entire coastal belt and adjoining areas. Climate in this region is hot with excessive rainfall during June through September. b) Savanna climate- Southern half of state experiences hot, seasonally dry tropical climate. c) Steppe type climate- most of the northern half of Karnataka experiences hot, semi-arid tropical climate. Climate of the state varies with the seasons and the three seasons are:

a) Premonsoon (February- May): It is characterized by a rapid shift of the greatest heat from south to north. March experiences highest temperature of about 35° C in Karnataka plateau. In May temperature may be as high as 39° C. During this month in the evenings dust storms followed by light rains are characteristic.

Table 1: Inflow and discharge of water at Bhadra reservoir

Year & Month	Reservoir water Level (mtr.)	Water Inflow (Million cubic mtr.)	Water discharge (Million cubic mtr.)	Surplus amount of water (Million cubic mtr.)
1999				
January	55.4	302.7	316.7	
February	53.1	127.4	269.5	
March	50.8	87.1	256.4	
April	47.9	102.4	240.8	
May	44.6	275.6	166.1	
June	43.2	2440.5	435.0	
July	46.0	11701.5	128.6	
August	56.0	7708.8	1585.3	3596.9
September	56.2	19885.6	374.6	
October	55.5	4122.2	611.5	76524.3
November	56.7	1158.2	285.3	
December	54.5	671.3	49.6	
2000				
January	49.7	238.4	287.8	
February	53.9	122.2	878.9	
March	51.0	100.3	432.0	
April	47.9	77.7	689.0	
May	44.0	64.9	471.6	
June	40.5	3071.0	43.5	
July	44.2	64.9	44.8	
August	50.9	7803.0	46.0	
September	56.0	4122.8	1032.0	194512.1
October	56.4	3036.5	886.8	546036.5
November	56.2	860.6	43.2	
December	55.2	255.4	800	

Source: Bhadra reservoir irrigation department, B R Project.

b) Monsoon (June- September): Arabian sea monsoon (South-West) strikes the Westren Ghat, causing heavy rain. Thereafter cyclonic depressions originating at the Bay of Bengal cross over into the main land (North-East). The intensity and frequency of these depressions are responsible for the overall strength and weakening of monsoon in a given year.

c) Postmonsoon (October to December and January): By October the intensity of rainfall becomes less. North-East monsoon winds gradually retreat leaving South India by early November. Cloud is still moistened due to prevailing high temperature (30° C), cool climate prevailing during these months.

Meteorological Conditions

Monthly data on air temperature, wind velocity, relative humidity, vapour pressure, evaporation and sunlight for the study period in the Bhadravati region procured from District Hydrometeorological center B.R. Project, Shimoga is depicted in Table 2.

Air temperature ranged from a minimum of 10° C in January 1999 and 12° C in December 2000, to a maximum of 38° C in March and April 1999 and 38° C in May 2000. Annual mean minimum temperature recorded in this area was 17.3° C in 1999 and 16.9° C in 2000 while annual mean maximum temperature recorded was 32.4° C in 1999 and 32.6° C in 2000 respectively. Premonsoon months recorded comparatively higher temperatures.

Wind velocity ranged from minimum of 4.1 mm/hr in October 1999 and 5.5 mm/hr in September 2000, to a maximum of 8.7 mm/hr in December 1999 and 9.3 mm/hr in June 2000 respectively. Premonsoon months recorded high values. Similarly the annual mean wind velocity recorded in this region was 6.9 mm/hr and 7.6 mm/hr during 1999 and 2000 respectively.

Relative humidity ranged from a maximum of 63 % in January 1999 and 69 % in January 2000 to a maximum of 85 % in July 1999 and 87 % in May 2000.

Table 2: Hydro-meteorological data of Bhadravati Taluk during 1999 through 2000

Year and Month	Rainfall (mm)			Temperature (° C)		Wind Velocity (mm/hr)	Relative humidity (%)	Vapour pressure (milibars)	Evaporati on (mm)	Sunshine (hr)
	Max	Min	Total	Maxi	Mini	Daily mean	Daily mean	Daily mean	Daily mean	
1999										
Jan				32.0	10.0	6.0	63.0	15.7	2.0	8.5
Feb				35.0	14.0	8.2	73.0	20.2	4.1	9.2
Mar				38.0	17.0	7.4	75.0	25.0	5.4	8.3
Apr	17.0	0.2	29.6	38.0	20.0	7.6	79.7	27.6	5.2	8.6
May	14.0	0.1	70.7	31.8	21.3	6.4	81.0	22.6	3.4	5.3
Jun	23.0	0.2	116.5	32.0	20.0	8.4	79.8	21.0	2.3	4.6
Jul	134.0	0.1	445.1	31.0	20.0	7.6	85.0	19.9	1.7	2.2
Aug	21.2	0.4	132.6	27.0	20.3	6.2	81.9	19.3	1.9	2.8
Sep	7.0	0.2	35.4	32.0	19.0	6.1	80.0	20.0	2.2	5.5
Oct	0.55	1.0	360.0	31.0	20.0	4.1	80.0	19.6	20.1	6.0
Nov	0.6	0.0	0.6	31.0	14.0	6.9	74.6	18.0	2.4	6.2
Dec				30.0	12.0	8.7	72.0	17.0	2.6	6.5
2000										
Jan				34.0	13.0	7.8	69.0	17.9	3.3	8.5
Feb				33.0	13.0	8.0	72.0	17.0	3.8	8.0
Mar				36.0	14.0	7.4	71.9	21.6	5.3	8.5
Apr	21.6	1.0	27.6	37.0	20.0	9.0	79.7	23.7	5.7	7.8
May	7.0	1.6	22.0	38.0	20.0	9.1	87.0	23.5	4.6	8.1
Jun	18.6	0.2	125.6	31.0	20.0	9.3	86.0	24.9	2.2	3.0
Jul	61.0	0.5	313.5	30.0	19.0	8.1	83.0	26.0	1.4	2.8
Aug	28.0	0.9	305.1	31.0	19.0	7.1	84.0	26.3	1.8	3.2
Sep	37.0	0.5	166.7	31.0	20.0	5.5	86.0	28.1	2.1	5.4
Oct	3.6	0.6	4.2	29.5	17.2	6.8	80.0	24.9	2.5	7.3
Nov				29.8	16.0	5.8	76.0	25.0	2.5	6.8
Dec				31.0	12.0	7.5	74.0	26.2	2.4	6.6

Source: District Hydro-meteorological Centre, Shimoga

Monsoon months recorded high relative humidity (83.15 %) than the premonsoon months (77.3 %) and post monsoon months (73.45 %).

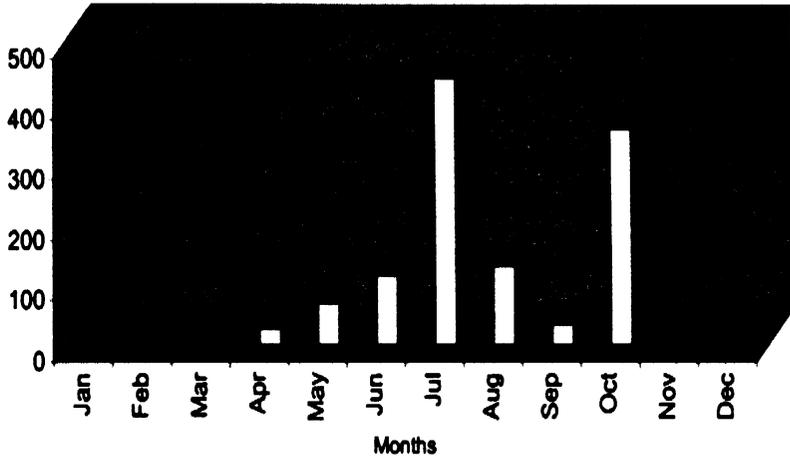
Annual mean humidity in this region was 77.0 % and 79.05 % during 1999 and 2000 respectively.

Vapour pressure recorded ranged from a minimum of 15.7 milibars in January 1999 and 17.0 milibars in February 2000, to a maximum of 27.6 milibars in April 1999 and 28.1 milibars in September 2000. The maximum vapour pressure (23.5 milibars) was experienced during monsoon months and minimum (22.6 milibars) during pre and post monsoon months. Annual mean vapour pressure witnessed in this region was 20.49 milibars and 25.17 milibars during 1999 and 2000 respectively. Similarly evaporation in this area ranged from minimum of 1.7 mm in July 1999 and 1.4 mm in July 2000, to a maximum of 5.4 mm in March 1999 and 5.7 mm in April 2000. In monsoon months, low evaporation of 1.9 mm (in monsoon) and high evaporation of 4.6 mm in premonsoon was apparent. Annual mean evaporation for this region was 2.95 mm and 3.13 mm during 1999 and 2000 respectively.

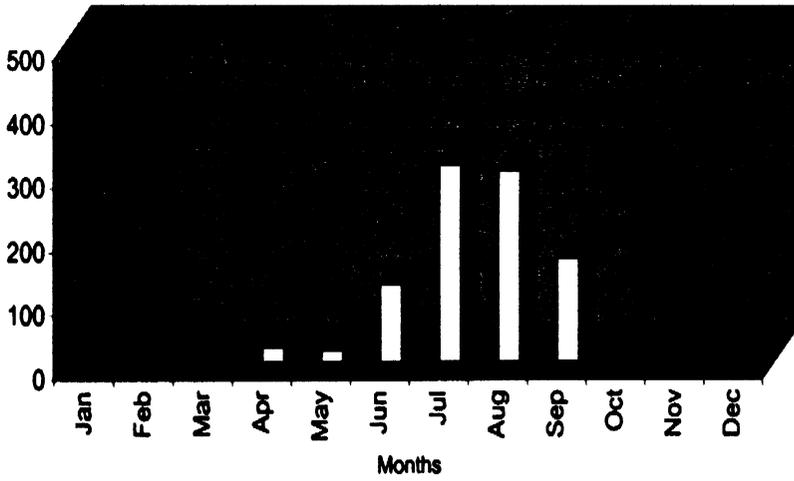
Sunshine noticed in this region ranged from a minimum of 2.2 hr in July 1999 and 2.8 hr in July 2000, to a maximum of 9.2 in February 1999 and 8.5 hr in January 2000. Average of 7.9 hr sunshine was experienced during premonsoon and an average (7.05 hr) during post monsoon months. Annual mean sunshine noticed was 6.1 hr and 6.3 hr during 1999 and 2000 respectively.

Monthly data on the precipitation recorded in the region of investigation for the study period is given in the Figures 3a and 3b. As can be seen from figure, Bhadravati region experienced a total rainfall of 1190.5 mm and 965.3 mm during 1999 and 2000 respectively. Months of July 1999 and 2000 recorded high precipitations of 445.1 mm and 313.5 mm. In the months of April 1999 and May 2000 low precipitations of 29.6 mm and 22.0 mm were recorded respectively. No rainfall occurred during November 1999 through March 2000. The average annual rainfall over the town is 822.4 mm. Based on the 20 years of rainfall from 1980, it

1999



2000



Figures 3 a and b: Rainfall pattern (mm) in Bhadravati taluk during 1999 through 2000

can be said that, in recent years Bhadravati region has been experiencing considerably diminished rainfall.

Sampling Sites:

A survey was made on the Bhadra river course near Bhadravati town (long. $75^{\circ} 42'$ East of Greenwich, lat. $13^{\circ} 51'$ North). Figure 4 details the course of the river near Bhadravati town. A low masonry weir constructed across the river facilitates sufficient depth for the intake of water for both domestic and industrial purposes. Between the weir and first Road Bridge (see Fig. 4), nearly a kilometer, river is restricted to the right bank during the dry months, exposing part of the river bed on the left margin. Due to this, large numbers of islands are formed which facilitate a good habitat for aquatic and avian fauna (Fig. 5). This stretch also receives the domestic effluents. From first Road Bridge to second Road Bridge, the presence of a large pool area serves as combined effluent area. On each side of this exposed area large number of vegetable gardens are present (Fig. 6) and cloth washing activities are also evident (Fig. 7). Smoke emitted by the two major industries has led to considerable contamination of air in this area (Fig. 8). Based on the information obtained by the survey, two sampling sites 3.5 km apart were identified for the collection of water, sediment, and plankton and bottom biota in the river.

Sampling site 1 (SS1):

This is located in the upstream (A kilometer from low weir), The course of river at sampling site 1 is tortuous and is composed of hard granite rocks forming steep bank with sand and gravel patches covering the bed. Exposed sand patch of bed is generally covered by vegetation, mainly shrubs bushy in nature. These are submerged during high water discharge (Fig. 9). During the low water level season, many pools and canals formed at this site are exposed (Fig. 10). Bottom of the river

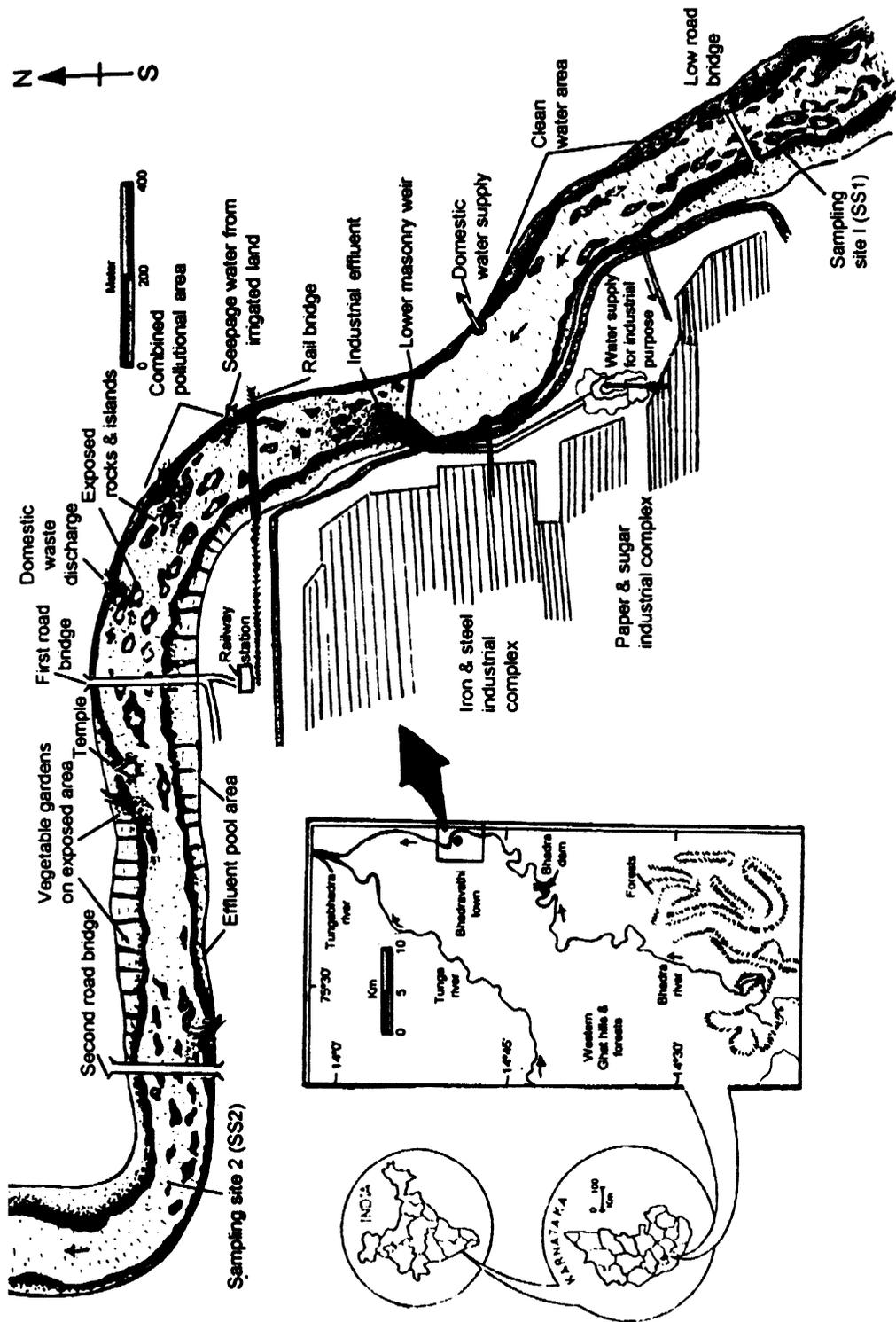


Figure 4 : Sketch map of Bhadra river near Bhadravati

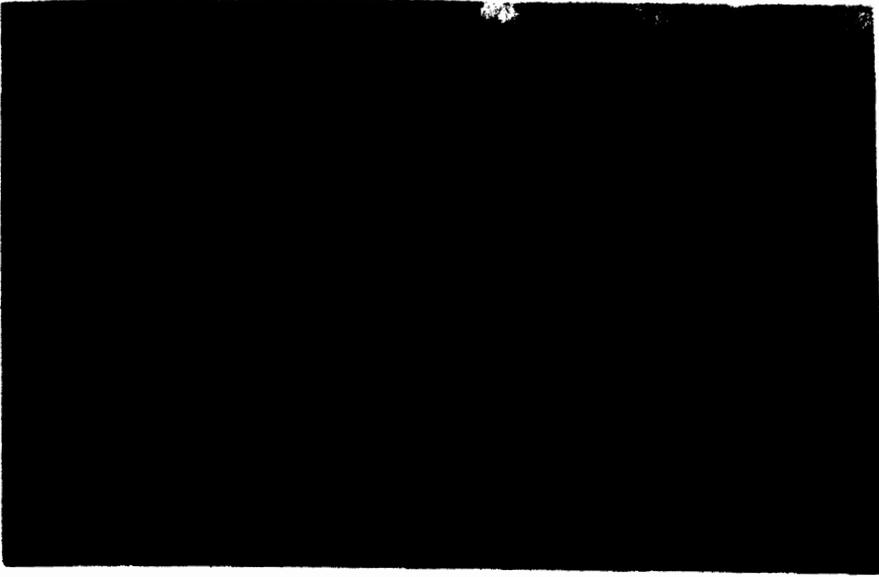


Figure 5 : Photograph showing number of islands between low weir and first road bridge in Bhadra river



Figure 6 : Photograph showing number of vegetable gardens on each side of exposed area between first road bridge and second road bridge in Bhadra river

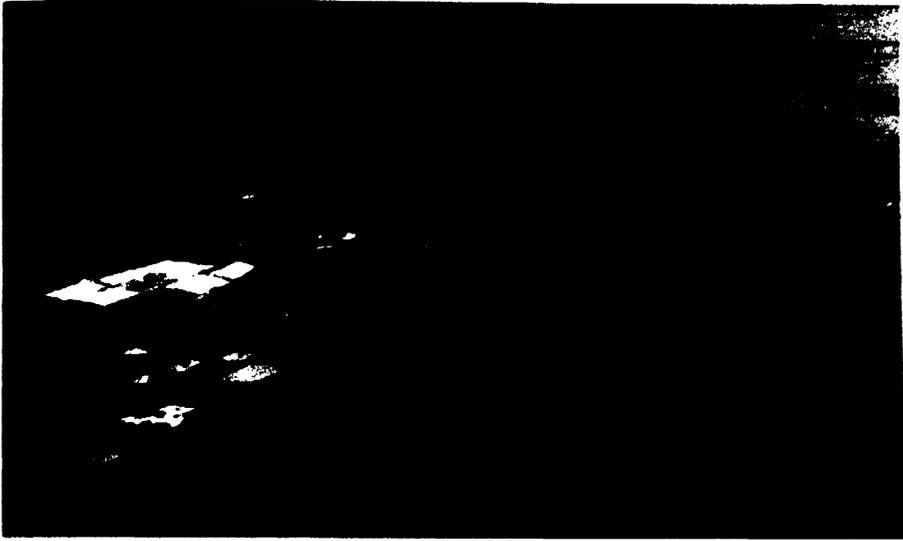


Figure 7 : Photograph showing cloth washing near first road bridge in Bhadra river



Figure 8 : Photograph showing the smoke released from the industrial complex in Bhadravati town



Figure 9 : Photograph showing high water discharge during monsoon month at SS1



Figure 10 : Photograph showing exposed rocks, canals and vegetation at SS1

at this site is composed of large rocks, stones and pebbles. The course of water is rapid with swirling.

Sampling site 2 (SS2):

This is located in the downstream (Two and half kilometer from low weir). The river course at sampling site 2 is moderately wide with sand and clay bottom and having deposition of pulp discharged from paper industries. Water in the river course is less rapid as compared to SS1 (Fig.11). At this site human activity is considerable and colour of water appears dark brown during discharge of wastes from industries (Fig.12). Water level reaches close to the bridge level during monsoon months (Fig. 13). During low water level, aggregation of the gastropod *Melania tuberculata*. (Fig. 14) and deposition of fecal matter by birds (Fig.15) on exposed rocks is very common.



Figure 11 : River course at SS2.



Figure 12 : Colour of water at SS2



Figure 13 : Water level at SS2 during monsoon months



Figure 14 : Aggregation of molluscs on exposed rock at SS2



Figure 15 : Birds and their excreta on exposed rocks surfaces at SS2