2. Study area

In central India, the Deccan Plateau is drained eastward by the third largest river of India, i.e. the Godavari River (Table 1), which has a catchment area of \(3.1 \times 10^5\) km\(^2\) (approximately 9.5\% of the total geographical area of the country). The catchment area is spread over five states, viz. Maharashtra, Andhra Pradesh, Madhya Pradesh, Orissa and Karnataka (Fig. 2) (Anonymous, 1989).

![Pie chart showing distribution of catchment area over the states](image)

Fig. 2: Distribution of Catchment area over the states (data from Anonymous, 1989)

The river basin lies between east longitudes 73°26' and 83°7' and north latitudes 16°16' and 22°36'. The basin is confined by the Satmala Hills, the Ajanta Range and Mahadeo Hills in the north, by Eastern Ghats in the south and east and by Western Ghats in the west. Principal tributaries of the river are the Pravara, the Purna, the Manjera, the Pranhita, the Indravati and the Sabari. Of these, the Pranhita with its major tributaries the Penganga, the Wardha and the Wainganga, is the most important tributary of the Godavari River. The mean annual water discharge of the Godavari River is \(1.1 \times 10^{14}\) l (Anonymous, 1995) of which 93-96\% occurs during the monsoon season. Sediment discharge is
also predominantly monsoon influenced, because 95% of the total annual load is transported in the wet season (July - September). The river transports $1.7 \times 10^6$ t sediments into the Bay of Bengal annually (Biksham and Subramanian, 1980 and 1988).

### Table 1: General features of major rivers on the Indian subcontinent

<table>
<thead>
<tr>
<th>River</th>
<th>Basin area $10^3$ km²</th>
<th>Water discharge km³/a</th>
<th>Sediment discharge $10^6$t/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ganges</td>
<td>980</td>
<td>590</td>
<td>520</td>
</tr>
<tr>
<td>Indus</td>
<td>970</td>
<td>240</td>
<td>59</td>
</tr>
<tr>
<td>Brahmaputra</td>
<td>580</td>
<td>630</td>
<td>540</td>
</tr>
<tr>
<td>Irrawady*</td>
<td>430</td>
<td>428</td>
<td>265</td>
</tr>
<tr>
<td>Godavari*¹</td>
<td>313</td>
<td>119</td>
<td>170 *</td>
</tr>
<tr>
<td>Krishna</td>
<td>250</td>
<td>32</td>
<td>4</td>
</tr>
<tr>
<td>Mahanadi</td>
<td>88</td>
<td>67</td>
<td>31</td>
</tr>
<tr>
<td>Narmada</td>
<td>88</td>
<td>47</td>
<td>7</td>
</tr>
<tr>
<td>Cauvery</td>
<td>87</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Tapti</td>
<td>49</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>


* Berner and Berner (1987)

*¹ Anonymous (1989)

# Biksham and Subramanian (1988)

The estuarine region of the river shows seasonal variation in its extent. Heavy monsoon rains over the basin and consequent water discharge by the river brings drastic changes in the salinity gradient in the estuarine region (Ramana et al., 1989). The distributaries (Gautami and Vashishtha Godavari) of the
river are full with fresh water in the peak season of monsoon (July); towards the end of monsoon (September) they are more or less partly mixed estuary, and in dry season (February) fully mixed estuary (Ramana et al., 1989).

**METEOROLOGICAL FEATURES**

The climate over this basin is semi-arid to monsoonal. Temperature ranges from 10°C in December-January to 47°C in April-May (mean 24°C). The delta region of the basin experiences periodic cyclones (Biksham and Subramanian, 1980). The Godavari basin receives its maximum rainfall during south-west monsoon, which accounts for more than 80% of the annual rainfall. On an average the basin receives 1062 mm rainfall annually. However, temporal and spatial variations in rainfall over the basin do occur (Anonymous, 1995). The rainfall data compiled from satellite based observations (Finch, 1994) shows that the monsoon rains are prevalent from mid of June till end of October, with sporadic rains during winter months (Fig. 3). The individual sections in this diagram depict a rather short period of rainfall in the upstream region of the river and longer period of rainfall in the downstream and over estuarine region. The diagrammatic presentation of the monthly discharge data provided by Central Water Commission, India, corroborate the above mentioned observation by showing a pattern (Fig. 4) peaking in the month of August.

**GEOLOGICAL FEATURES**

Sediment and solute transport by a river depend primarily on the rock formations in the catchment area (Biksham and Subramanian,
Prepared from the data averaged over 5 yrs, 1986 - 1990.
(This format more or less fits over the river basin)

Fig. 3: Rainfall pattern over the Godavari River basin
Average water discharge rate of the Godavari River
at Polavaram

Fig. 4: Average water discharge rate of the Godavari River
In general, the basin geology (Fig. 5) consists of tertiary Deccan Traps, Archean Granites, Precambrian and Gondwana sedimentary rocks and recent alluvial cover (2% of the basin area). In order to understand the extent of influence of basin geology on sediment transport, rock types in the Godavari basin are, based on their erodibility, categorised (Biksham and Subramanian, 1988) as follows:

a. **Granite and Hard rocks:** Granites, Charnokites and similar hard rocks and account for 39% of the basin geology. The river tributaries draining through these relatively stable and weathering inefficient rock formations carry low sediment loads. Weathering process in these type of rocks may be enhanced by formation of joints, cracks, faults etc.

b. **Deccan Traps:** The rock formations in this region are volcanic in origin and belong to the Tertiary age. They are known for their distinct spheroidal weathering and fluvial erosion. The whole area is covered by 10-40 cm thick black clay loam, which may be released to the river as suspended sediments. The Deccan Traps occupy nearly half (48%) of the basin area and contribute almost the same proportion of sediments.

c. **Sedimentary rocks:** The sedimentary rocks located in the central and lower part of the catchment area (11% of the total basin area) are of Precambrian and Gondwana age. They consist of sandstones and quartzite with a few slate bands. The sandstones originating in Gondwana age are mostly argillaceous in nature and
Fig. 5: Geological features of the Godavari River basin.
interbedded by shales. These rocks are known for their high degree of erodibility.

**EDAPHOLOGICAL FEATURES**

In modern terminology, following soil orders with sub-order variations have been reported in the Godavari basin: Aqualfs (high base status soils, hydromorphic), Aquepts (brown soils, hydromorphic), Fluvents (alluvial soils, recent soils), Ochrepts (shallow black, brown and alluvial soils of northern-region), Orthents (recently formed soils), Tropepts (shallow black brown and alluvial soils of southern-region), Udalfs (high base status soils of humid regions), Ustalfs (high base status - red loamy, red sandy and alluvial soils), Usterts (deep black soils), Ustolls (grassland soils of sub-tropical regions) and rock outcrops (Census of India, 1981). Orthents are largely confined in the western half and in a small zone on eastern boundary of the river basin (Fig. 6). Usterts are prevalent in the central part, with considerable extensions towards western part, of the basin. Eastern part of the basin is dominated by Ustalfs. In the lower reaches, close to and in the estuarine region, soil type varies within relatively short distances.

Soil sub-order associations as depicted in Fig. 6:

3  Aqualfs - ustalfs
7  Ustalfs
9  Ustalfs - Ochrepts
11 Ustalfs - Ochrepts - Aquepts
12 Ustalfs - Tropepts
14 Ustalfs - Ustolls
15 Ustalfs - Rock outcrops
55 Orthents - Tropepts - Rock outcrops
Fig. 6: Soils of the Godavari River basin
ANTHROPOLOGICAL ACTIVITIES

The Godavari River basin has 1.9x10^5 km^2 cultivable area (9.7% of the total cultivable area of the country). Exploitation of ground water for irrigation and other uses has been taking place at a faster rate, still this utilisation is ca. 13% of the estimated utilisable potential. The utilisable surface waters of the basin have been estimated to be 76.30 km^3 per annum, which has led to formulation of a number of large and small water resource development projects. Many storage and diversion projects were taken up during pre-plan period e.g. Godavari delta system, Polavaram irrigation system, Nizam Sagar reservoir, Kadwa dam and Pravara dam. Some of the completed hydroelectricity projects in the basin are Donkaraoi (25 MW), Machkund (25 MW), Srisrumsagar (47 MW), Jayakwadi (12 MW), Veldari (18 MW), and Balimela (65 MW). The estimated hydroelectric power generation potential of the basin is ca. 5091 MW, but only 1320 MW is currently being harnessed and constructions for tapping another 1292 MW are going on (Anonymous, 1989 and 1995). These small and large scale projects
are of special interest in river basin studies as they create localised imbalances in sedimentation and erosion processes.

According to 1981 census, city of Nagpur with 12.98 lakhs people is the most important urban centre in the Godavari basin. Other important cities in the basin are Nasik (4.28 lakhs), Aurangabad (3.16 lakhs), Warangal (3.36 lakhs), Rajahmundry (2.68 lakhs), Akola (2.25 lakhs), Amravati (2.61 lakhs) and Ahmednagar (1.81 lakhs). Industries in this basin are based on agricultural produce, e.g. rice milling, cotton spinning, weaving, sugar and oil extraction. Some industries on cement, fertilisers, paper and engineering goods also exist (Anonymous, 1989). Mining of coal, limestones, slates, manganese and iron ore is among important human activities in the basin.