

Water balance approximation for the Vedavati River in semiarid Anantapur district, Andhra Pradesh, India

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Abstract. The Vedavati River has its origin in the Karnataka plateau and drains parts of southern Peninsula India, ultimately joining Thungabhadra River. It has a basin area of 2350 km² mostly in granitic terrain. By critical studies the climatic, meteorological and hydrological data available have been analysed. Precipitation during August–November contributes to the flood of the Vedavati. A detailed description and evaluation of gravity springs and baseflows have been attempted. Soil salinization and alkalization are major problems in tank irrigated and canal irrigated areas. The distribution of land forms, soils in minor stream basins and their contribution to tank sedimentation are discussed and the groundwater component of the water balance approximated. Measures are suggested for intercepting the excess runoff for surface and subsurface storage, to enhance the irrigation potential of the area.

Estimation du bilan hydrologique de la rivière Vedavati dans le district semi-aride d'Anantapur, Andhra Pradesh, Inde

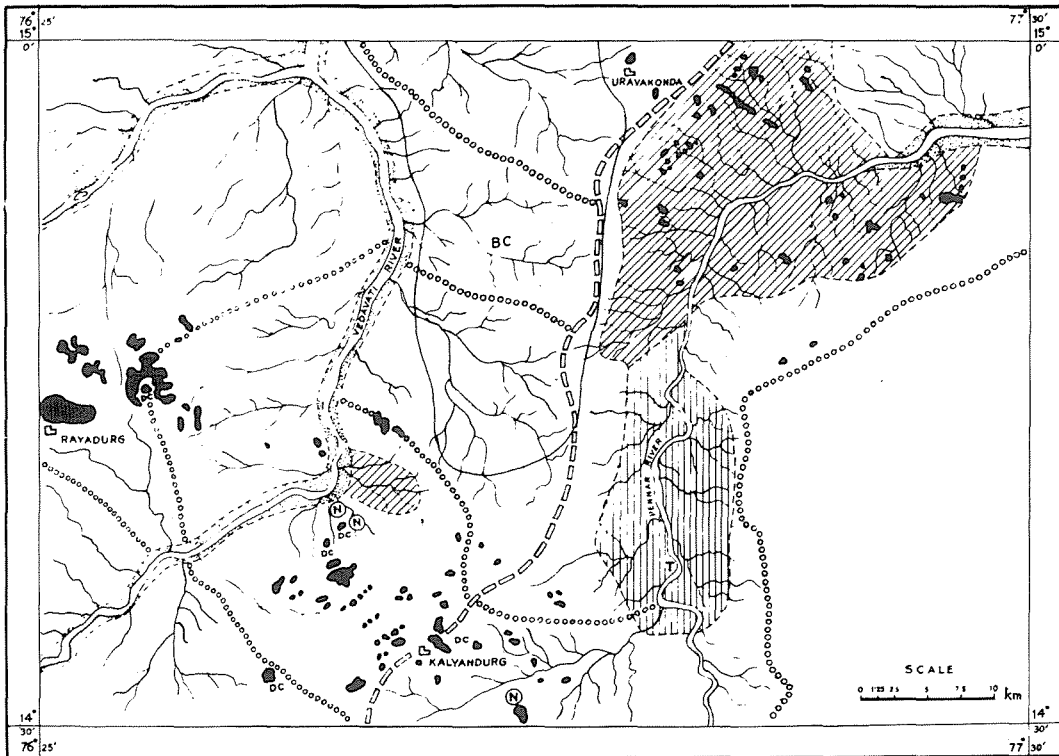
Résumé. La rivière Vedavati prend sa source sur le plateau de Karnataka, Draine une partie du Sud de la péninsule indienne et, finalement, se jette dans la Thungabhadra. La surface de son bassin est de 2350 km² pour la plupart en terrain granitique. Par des études critiques, les données climatologiques, météorologiques et hydrologiques disponibles ont été analysées. Les précipitations qui se produisent d'août à novembre contribuent aux crues de la Vedavati. Une description détaillée et l'évaluation des débits de sources et du débit de base ont été tentées. La salinisation et l'alcalinisation du sol sont les problèmes les plus importants à résoudre dans les zones irriguées par des canaux et par des réservoirs. La répartition des formes géomorphologiques, des sols dans les petits bassins versants et leur contribution à la sédimentation dans les réservoirs, ont été analysées et on a quantifié le bilan des eaux souterraines. On suggère des mesures pour récupérer le ruissellement superficiel en excès, pour l'aménagement de réservoirs de surface et souterrains et pour améliorer le potentiel d'irrigation de la région.

INTRODUCTION

The Vedavati basin is situated in southern Peninsular India. Detailed investigations were carried out in an area of 2350 km² in the semiarid Anantapur district to find the approximate water balance (Fig. 1). The area is underlain by granites and migmatites. The altitude of the area ranges from 1000 m in the south to 400 m in the north. Conspicuous breaks of slope marked by zonal inselbergs and residual hills are seen in the area. The granitic peneplain is etched (weathered) to depths of up to 22 m below ground level. Minor stream valleys incise the etch plain to form the tributary network of the Vedavati River. Surficial deposits comprise red sandy soils, organic rich clayey black soils and terrace alluvium fringing the Vedavati River. Extensive rain-fed agriculture over 80 per cent of the area has resulted in a reduction of the vegetation cover. Vegetation comprises stunted *Acacia* shrubs, *Euphorbia* and the annual grass *Scutia indica* confined to isolated forest reserves. The saline floors of minor stream valleys are colonized by local *Phoenix sylvestris*. Droughts are a common phenomenon in this semiarid parched land of Peninsular India.












CLIMATE

As pointed out earlier, Anantapur district falls in the semiarid zone of south India. The aridity in this area is characterized by low annual precipitation (Kanekal 389 mm;



I N D E X

LAND FORM

-  DOMED INSELBERGS
-  DISSECTED ETCH PLA
-  HIGHLY DISSECTED TERRAIN
-  TOR AND CORESTONE TERRAIN
-  FLOOD BASIN
-  ORGANIC RICH BLACK COTTON SOIL
-  ROCK DEBRIS CONE
-  + 2m. CALCRETE CEMENTED GRAVEL TERRACE
-  NEOLITHIC SETTLEMENT
-  MAJOR RIVER VALLEY DIVIDE
-  MINOR STREAM VALLEY DIVIDE

AGE

- PALEOZOIC AND TERTIARY
- PLEISTOCENE
- END-PLEISTOCENE
- END-PLEISTOCENE
- EARLY HOLOCENE
- EARLY HOLOCENE
- END-PLEISTOCENE
- END-PLEISTOCENE
- EARLY TO LATE HOLOCENE

SCALE
0 2.5 5 7.5 10 Km

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FIGURE 1. Geomorphological map of the Vedavati and Pennar basins.

Kalyandurg 520 mm) erratically distributed from season to season, a high solar radiation of more than $450 \text{ cal cm}^{-2} \text{ day}^{-1}$ and a wind velocity of 12–16 km/h resulting in a high annual potential evapotranspiration of 1857 mm. Rainfall is erratic and on the average falls on only 34 days a year. Desiccating winds blow from April to August with speeds progressively increasing from 12 to 16 km/h.

HYDROLOGY

The Vedavati River has its source in the northerly sloping Karnataka plateau, drains an area of 2350 km^2 in Anantapur district and ultimately joins Thungabhadra River in the north. The river is largely fed by precipitation received from September to November (southwest monsoon) each year. The annual rainfall in the basin averages from 389 to 520 mm. About 80–95 per cent of the precipitation falls during the southwest monsoon when peak discharges occur. Following the period of maximum flood, monthly discharges drop off rapidly to reach minimum levels of baseflow during January–July. Mostly precipitation occurs in short spells during the passage of cyclonic depressions which originate from the Bay of Bengal. Raingauge stations are located at five stations in the Vedavati basin in Anantapur district. As an example the streamgauge records of Ramapuram station from 1971–1974 are presented in Table 1.

In the absence of streamgauge stations in the investigated areas, a runoff value of 14 per cent was obtained by applying the Inglis formula of Murray (1971). A runoff value of 14 per cent was arrived at during a normal year of rainfall by the Central Groundwater Board (Ramesham and Achuta Rao, 1978) in other districts of the basin. The 14 per cent runoff value was linked with the flow at Ramapuram streamgauge station recorded during a normal rainfall year. It is observed that normal runoff falls to 12 per cent during years of deficit rainfall (drought years) and increases to 16 per cent during years of excess rainfall.

SURFACE WATER SOURCES

Tanks, gravity springs and spring channels form important minor irrigation sources in the Vedavati basin. The major sources of irrigation in the basin are the Thungabhadra high level canal (imported water) through which $200 \text{ m}^3/\text{s}$ of water are imported annually and the B.T. project across the Vedavati near B. Tippa with a storage capacity of $26 \times 10^6 \text{ m}^3$ to irrigate 4800 ha of land.

Gravity springs

Gravity springs are the traditional irrigation sources of the area. They emerge from the mid-basin areas in the basins of minor streams through fractured zones in the sandy alluvial floors. In most cases trenches have been excavated from the spring heads to receive the additional supplies. These are of the nature of infiltration ditches. These springs are mainly intermittent due to the erratic distribution of precipitation. The discharge from these springs varies from year to year depending on the rainfall. In

TABLE 1. Discharge of the Vedavati River at Ramapuram station [m^3/s]

Year	J	F	M	A	M	J	J	A	S	O	N	D	Annual
1971	9	4	3	2	7	8	6	21	67	133	25	24	30
1972	13	3	1	1	55	25	6	7	92	49	26	17	20
1973	8	3	1	1	2	32	11	53	98	124	34	22	32
1974	11	9	2	2	11	10	9	19	125	157	36	30	35

recent years, more than 50 per cent of these springs failed due to over draft of groundwater. These springs normally supply 250 ha of cultivable land during years of normal rainfall.

Spring channels

Spring channels are the traditional sources of groundwater and date from the eleventh century. Their operation involves excavation of the sands of the Vedavati River on the down gradient. Baseflows from the rivers are diverted through the spring channels to irrigate alluvial plains for 1–4 km. The spring channels, on excavation, supply valley fill alluvial groundwater (bank storage) through infiltration. These channels are usually 1–1.5 m wide and have a depth of 1–2.5 m below bed level. The discharge from spring channels is from $3.16 \text{ m}^3/\text{s}$.

QUALITY OF GROUNDWATER

Groundwater from fractured and weathered aquifers is potable. Wells located in areas irrigated by tanks and canals and in valley floors of minor streams generally yield saline waters due to poor drainage and high evapotranspiration so characteristic of semiarid areas. Groundwaters recovered from black soils show abnormal concentrations of salts (TDS range 1152–4352 ppm). Out of $4555 \times 10^4 \text{ m}^3$ of groundwater computed from the water balance for the Vedavati basin, $2325 \times 10^4 \text{ m}^3$ are of poor quality brackish waters from black soils.

WATER BALANCE

A balance of $213.58 \times 10^4 \text{ m}^3$ of surface waters and $4555 \times 10^4 \text{ m}^3$ of groundwater are potentially available for exploitation in the Vedavati basin. Subsurface dykes and detention reservoirs could be planned along minor stream valleys to intercept excess runoff and for recharging the aquifers.

Soil erosion

About 80 per cent of the basin area is under rain-fed agriculture. Soil erosion results in formation of gritty veneers, and accumulation of sands in drainage cause tank siltation and drainage congestion. It is estimated that 4.9–18 t of topsoil are being removed from each hectare of the basin surface annually.

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- Ramesham, V. and Achuta Rao, A. (1978) An approach to the use of repeat MSS imageries for Vedavati catchment in Karnataka and Andhra Pradesh. *J. Geol. Soc. India.* **19**, no. 7, 326–331.