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Groundwater depletion and groundwater balance studies of Kandivalasa River Sub Basin, Vizianagaram District, Andhra Pradesh, India

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ABSTRACT

The Kandivalasa River Sub Basin near Cheepurupalli town of Vizianagaram district, Andhra Pradesh, India was monitored for groundwater levels at 41 observation wells during 2013–2015. Along with groundwater levels, the daily rainfall data is also collected for these years. A continuous decrease in groundwater levels was observed during the study period more particularly in the year 2015 which also had minimum rainfall. Groundwater depletion is observed mostly in the Eastern and South Western part of the basin where pumping wells are more. Groundwater balance studies have indicated that 11.3 MCM of groundwater can be utilized in the basin annually. However, the net annual groundwater draft has been found to be 16.6 MCM. Hence, over abstraction of 5.66 MCM is the main cause for depletion of groundwater levels. The water conservation and groundwater recharge measures have to be taken up at Chinnanadipally and Dummeda villages in the basin to have sustainable groundwater utilization in the basin.

1. Introduction

India is currently the world's largest consumer of groundwater, withdrawing more than double the amount of groundwater drawn by the USA (Shah, 2005). Over the years, increasing dependence on groundwater has created imbalance in the groundwater availability and long term withdrawal is exceeding long term recharge, leading to the depletion of groundwater level. Since agriculture is the main occupation in the study area which is Kandivalasa River Sub Basin (KRSB) near Cheepurupalli town of Vizianagaram district, Andhra Pradesh, India, the farmers are mainly dependent on groundwater for irrigation in non-monsoon period (November to May). To meet the challenges of depleting groundwater levels and thereby drying up of bore wells in the non-monsoon season, the management and development of groundwater resources is essential in the study area. Hence, it is very important to know about the extent of natural recharge occurring to the aquifer of the region. Moreover, the groundwater recharge estimation is a key component in groundwater flow or transport models.

Satish Chandra and Saksena (1975), Athavale et al. (1992), Kumar and Seethapathi (2002) have carried out groundwater balance studies and quantified groundwater resources in various hard rock regions of India. Naga Rajani et al. (2006), have used remote sensing and GIS techniques for groundwater exploration and identification of artificial recharge sites in Kurmapalli watershed in Nalgonda and Ranga Reddy districts of Telangana, India. Rangarajan et al. (2009) have estimated the natural recharge and its relation with aquifer parameters near Tuticorin Town, Tamilnadu, India. Varalakshmi et al. (2014) have studied the groundwater recharge studies by using GEC-1997 guidelines in the Osmansagar and Himayathsagar catchment areas which are comprised of basaltic and granitic terrains respectively in the Telangana State. The study has concluded that the percent rainfall converting to the groundwater recharge is nearly 22% in the basin. Khadri and Moharir (2015) have analyzed the seasonal groundwater fluctuations with reference to the rainfall received by the Man River Basin, Maharashra, India. The study also interpreted that the high level extraction of groundwater during non-monsoon period for irrigation purpose is causing groundwater fluctuation in the study area.

The main objective in this study is to evaluate the existing groundwater resources and stage of development (percentage of renewable groundwater utilized annually) in the Kandivalasa River Sub-Basin by using Groundwater Estimation Committee (GEC) methodology (GEC, 1997). For sustainable development of water resources, it is imperative to make quantitative estimation of the available water resources. These studies can be useful for overall development of the basin on sustainable basis.

2. Hydrogeology of the study area

Kandivalasa River Sub-Basin (KRSB) (Fig. 1) near Chipurupally town of Vizianagaram district of Andhra Pradesh, India, is covered with

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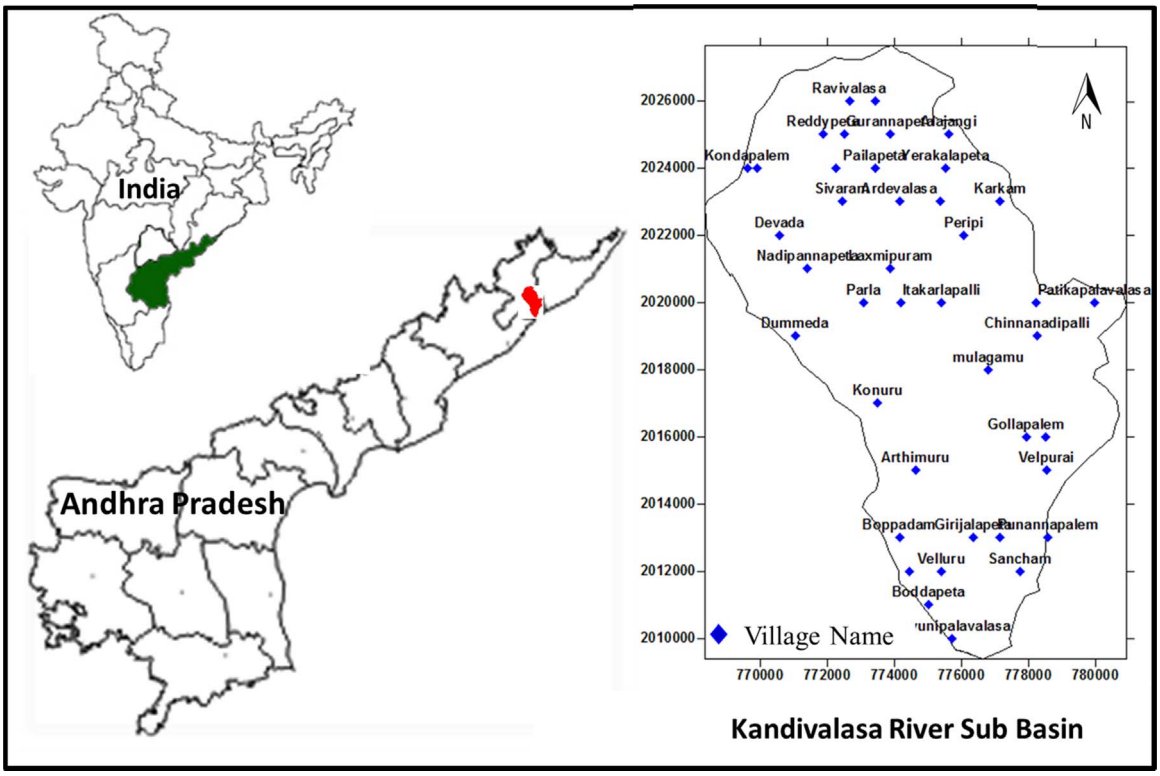

Fig. 1. Location of Kandivalasa River Sub Basin in the Vizianagaram District.

a typical khondalitic suite of rocks and is situated between east longitudes 83°32′15" to 83°39′10" and north latitudes of 18°9′15" to 18°19'54" having an areal extent of 121 km^2 is selected for this study. It forms a part of Survey of India toposheet nos. 65 N/11 and 65N/12. In general the area is covered by a thick soil cover (1–4 m) followed by weathered and fractured khondalitic formation underlain by basement of granite gneiss. The area is highly disturbed due to folding, faulting and fracturing with isolated hills covered by khondalitic rocks on the top and lateritic soils on the sides (Fig. 2). Occasionally quartz veins are seen exposed to surface often serving as guide to locate high yielding wells. The topography of the area is undulating. At all locations between hills there is a high slope in the foot hill region and a gentle slope towards the valley (Fig. 3).

Frequently small plateaus are also observed. The average annual rainfall is around 1000 mm. Groundwater occurs under water table conditions in the weathered portion of the khondalite. The fact that the raise of water level in the bore well after penetrating the fractured environment and drying up of nearby open wells due to pumpage of bore wells, demonstrate that the weathered and fractured environment are hydraulically connected. Therefore, the fractured environment is under semi confining conditions (Venkateswara Rao and Briz Kishore, 1991).

3. Methods

The groundwater levels of the 41 observation wells covering entire Kandivalasa River Sub Basin are monitored for both pre and post monsoon seasons of 2013, 2014 and 2015 (Plate 1). The GPS survey has been done at all the observation wells. Groundwater contour maps in the basin are also prepared by using SURFER software (Oseji Julius, 2011) to know the direction of groundwater flow. The daily rainfall data of five mandals (an administrative unit within a district) namely Cheepurupally, Garividi, Nellimarla of Vizianagaram district and Ranastalam and Laveru mandals of Srikakulam district covering entire basin is also collected from Andhra Pradesh State Economics and Statistics department. The monsoon rainfall is estimated for each mandal (Table 1). The seasonal changes of groundwater levels of all the individual wells are carefully observed from the year 2013–2015. The analysis of depletion of groundwater levels during this period has been carried out in the basin by using well census data and rainfall data (Nandargi et al., 2014) of the basin. The groundwater fluctuation map (Chyan-Deng et al., 2007) is prepared for the year 2015 using SURFER software.

In order to find out the causes for the groundwater depletion scenario in the basin, the groundwater recharge, the groundwater abstraction and the groundwater balance in the basin are estimated by using GEC-1997 guidelines (Kumar, 2012). The stage of the groundwater development is calculated (Sitender and Rajeshwari, 2015) and finally the groundwater recharge areas and pumping areas are identified with the help of groundwater flow maps (Singhal and Gupta, 2010).

3.1. Water-table fluctuation method

The study of groundwater level fluctuations helps to understand the depletion and recharging conditions of an aquifer. Physical-based techniques like water-table fluctuation method have traditionally and widely been used more than chemical based techniques for estimating groundwater recharge in semiarid regions (Healy and Cook, 2002). The groundwater recharge has been calculated by using Water Table Fluctuation method (WTF method) as per methodology recommended by Groundwater Estimation Committee (GEC, 1997). The water table fluctuation method is based on distinct changes in seasonal (pre and post monsoon) groundwater levels. Among the physical methods, the water-table fluctuation method links the change in groundwater storage with resulting water table fluctuations through the storage parameter (i.e., specific yield in unconfined aquifer).

The WTF method is based on the recharge effect, i.e. the rise of the water table due to previous rainfall. Careful analysis of the records enables the exclusion of variations in the water table due to fluctuations