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Integrated Geohydrological Studies in the Sedimentary Part of Gadilam River Basin, Cuddalore District, Tamil Nadu

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ABSTRACT

Water is a precious natural resource, without which there would be no life on Earth. Human beings body weight is also composed of two-third water. Our day to day life depends on the availability of inexpensive clean water and safe ways to dispose it after use. As a source of water, groundwater obtained beneath the earth's surface is often cheaper, more convenient and less vulnerable to pollution than surface water. Gadilam river basin covering sedimentary part lies between Latitudes 11°25'00 to 11°45'00 N and Latitudes of 79°18'00 to 79°47'60 E. Earlier Public Works Department (Government of Tamil Nadu), 1992 has done geohydrological field data collection including geological mapping; meteorological data was collected from Public Work Division (PWD); Remote sensing study was done through Landsat TM satellite imagery. The Landsat TM and SRTM satellite images were geometrically rectified with reference to the Survey of India (SOI) topographical sheets of 1:50,000 scale using ERDAS IMAGINE 8.7 software. From SOI toposheets and later using linearly stretched False Colour Composite (FCC) of Landsat TM satellite data and by using other image processing techniques were used to interpreted to map the geomorphology of this region. Water table fluctuations map was prepared using pre and post monsoon water level data. Water level fluctuation map is prepared by using spatial analyst tool of Arc GIS software. From the fluctuation map, it was found that maximum recharge is found in the central and southern part of the study area as water table is occurring at 43 m below the ground level. North-Eastern and western part of the study area shows minimum rise in water level with less than 7 m.

Key words: Geomorphology, water table fluctuation, remote sensing, GIS

INTRODUCTION

The Growing pressures on land for food, fibre and fodder in addition to industrial expansion and consequent need for infrastructure facilities has eventually given rise to ever increasing population, which intern has given rise to competing and conflicting demands on land and water resources where its occurrence is also a finite one. About 175 mha of land in India, constituting about 53% of her total geographical area, suffers from deleterious effect on soil erosion and other forms of land degradation. Keeping in view of the exploding population and a need for food security of the future generation, it is realized that the water and land resources need to be developed and managed in an integrated and comprehensive manner. It has been already realized that the soil and water conservation measures carried out on a watershed basis play a prominent role in this strategy of comprehensive land and water management. Hattermann *et al.* (2004) has presented a paper in integrated catchment model and a method with which it is possible to analyze local water table dynamics inside sub basins along with river flow in the regional scale. Moon *et al.* (2004) have analysed hydrographs and water-table fluctuation statistically to estimate groundwater recharge.

Many authors like Narasimhan (1965), Balasubramanian and Sastri (1989) Sathyamoorthy *et al.* (1997) and Aravindan *et al.* (2005) have computed aquifer parameter in different formations. Groundwater modeling studies helped to evolve quantitative understanding of vertical flow and for better quantification of spatio temporal variations of geohydrological variables (Thangarajan, 2004; Aravindan and Manivel, 2005). The present study was an attempt to study the water table fluctuation there by occurrence of possible recharge conditions and to determine the groundwater flow direction.

MATERIALS AND METHODS

Experimental design

Study area: The study area (Fig. 1) sedimentary part of Gadilam river basin lies between Latitudes 11°19'00 to 11°40'00 N and Latitudes of 79°19'00 to 79°47'50 E. Public Works Department (Government of Tamil Nadu), during 1992 and under United Nation Development Program has carried out studies in the entire Gadilam river basin covering both sedimentary and hard rock aquifers in the east while composite South Arcot district of Tamil nadu, India.

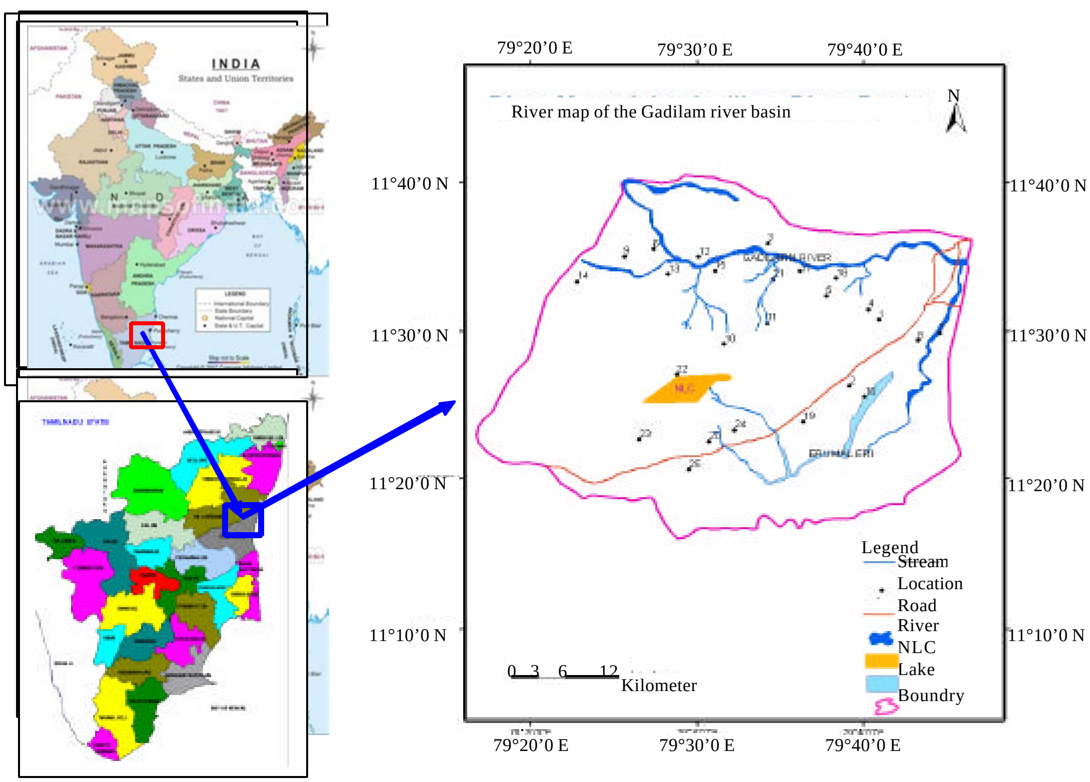

Fig. 1: Location Map of the study area

The overall climate of the area is warm and dry. Average temperature in the area is around 28°C. The maximum temperature attained is around 38°C in summer (May) and minimum temperature is around 25°C in January. The annual rainfall ranges from 995 to 1300 mm from west to east. Generally the rainfall is highest along the coast and less in the uplands of west. The mean monthly rainfall of 185 mm occurs during November.

The drainage pattern in the area is found to be sub dendritic. Study areas northern boundary is bounded by the drainage divide of major Ponniyar River. The study area is characterized by gently undulating topography with low relief sand stone and lateritic hills.

METHODOLOGY

Methodology adopted for achieving the above mentioned objective is as follows. There are three major components in this study they are a) Field data collection including geological map; b) Water level data was collected from Public Work Division (PWD); c) Remote sensed Landsat TM satellite imagery along with SRTM satellite image was geometrically rectified with reference to the Survey of India (SOI) topographic sheets in the scale of 1: 50,000 using ERDAS IMAGINE 8.7 software. The drainage pattern was initially derived from SOI toposheets and later updated using linearly stretched False Colour Composite (FCC) of Landsat TM satellite data and from other image processed outputs were used to interpret drainage and geomorphology of this region. Water Table and water level fluctuation map is prepared by using spatial analyst tools of Arc/GIS (9.3) software.

RESULTS AND DISCUSSION

Geology: Gadilam River enters the sedimentary part of the basin from the Archaeon- sedimentary contact at Thirunavallur in Ulundurpet Taluk and traverses via Thiruvamur where Malattar confluence's the main Gadilam before confluencing at Bay of Bengal. Uppanar a back water stream joins Main Gadilam East of Dhevanampatnam in Cuddalore. The Sountern part of the study area is drained by Manimutharu and Main Vellar River. The study area is also covered by rocks of the recent age. Central part of the study area was found to have river alluvium derived from tertiary rocks which comprises of lignite deposit and coastal alluvium adjacent to coast. As it is the sedimentary basin, hydraulic boundary was extended upto the two river boundaries in the south. The Fig. 2 shows the Geological map of the study area. The study area comprises of two major hydrogeologic environments (a) Recent Alluviam and (b) Sandstone found in Lateritic terrain. The average depth to water level ranges from 5 to 45 m. The recharge areas constitute about 50% of the basin. The productive aquifers are met at a depth of 60 m below ground level depending on the topography and rock type.

Geomorphology: In recent years the increasing use of satellite remote sensing has made it easier to define the spatial distribution of different ground water prospective classes on the basis of geomorphology and other associated features. The delineation of the geomorphic units is based on the interpretation of remotely sensed satellite data along with field observations made like topography, relief and other associated features on soil and vegetational covers.

Land forms: The present day landforms are irregular outline of ongoing different geomorphic and related neotectonic process. The rate of deposition and erosion is never found uniform because of the occurrence of uneven outcropping ridges and hills. By careful observation of various outcrop

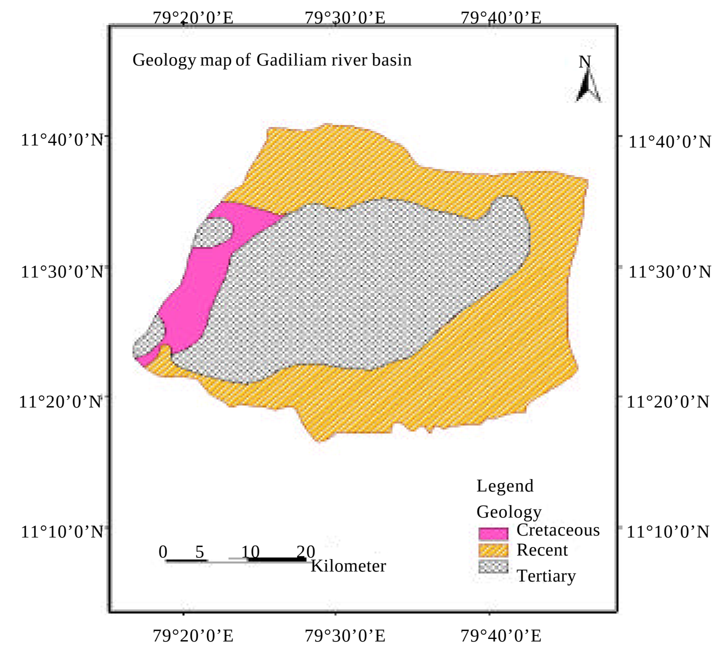

Fig. 2: The Geology map in the sedimentary part of Gadilam river basin

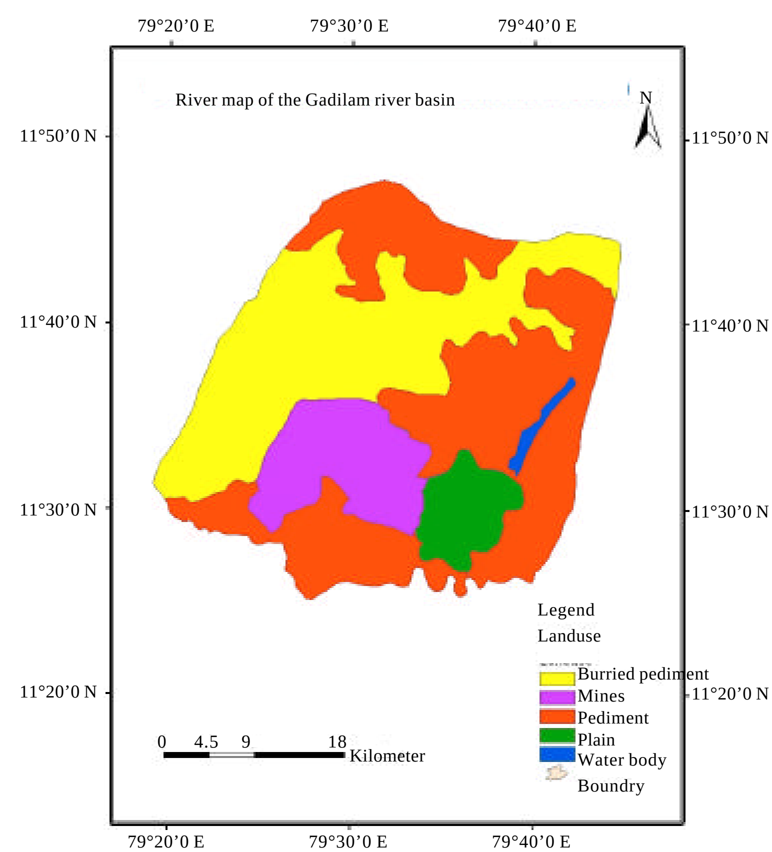

Fig. 3: Geomorphology of the study area

patterns with the help of Landsat imageries, the characteristic land form is recognized. The following are the landforms present in the study area (Fig. 3).

Denudation forms:

- Buried pediment
- Pediments

Pediments: In many arid and semi-arid regions long, smooth rocks cut plains extends out at varying distances up to several miles from mountain fronts. These plains are called as pediments. The pediments are the plains of degradation. A pediment may or may not have an alluvial veneer over it but it is basically rest over bed rock surface. The pediment is located as an intermediate landform between inselberge and shallow pediments. The groundwater condition in pediments is expected to vary depending upon the type of underlying folded structures, fracture systems and degree of weathering. Groundwater potentiality in pediments can be considered to be normal to poor (Sankar *et al.*, 1998) but presence of lineaments or fractures can provide some scope for movement of groundwater and hence may be the prospective zones for groundwater exploration. Bore wells located in shallow and buried pediments have deep water table condition when compared to those in pediments. In the study area pediments occupies the northwestern and southeastern part of the study area. These units are mainly covered in between NW and SE (the central part) of the study area (Fig. 3).

Buried pediments: Comprises of weathered sandstone (mottled) at considerable depths. Groundwater prospect is found to be good in buried pediments because tube wells are located in buried pediments which have shallow water table condition when compared to pediments, as recharge of groundwater is found to be high through fraiable and mottled formations. Burried pediments occupy the north eastern and south western part (Fig. 3).

Water table: Ground water level data has been collected from 25 observation wells in the study area. It is a well established fact that the occurrence and movement of groundwater depends upon lithology, landforms and the structure. If these factors are favorable then the aquifer condition holds good for good groundwater potentiality. A good aquifer is one which can be recharged during the period of monsoon when rain water gets infiltrated and recharged. This means that during the pre monsoon period the aquifer used to have a deep water table condition compared to post monsoon period. The difference in water table can be calculated once the water table of both seasons is recorded. From the water level data, existing 25 wells were considered for both pre and post-monsoon season (Fig. 4). Wells were found to be fairly distributed throughout the study area. Water table conditions of pre and post monsoon season are shown in Table 1.

Pre-Monsoon water table: Water level data of pre monsoon period was collected for the year 2007. Depth to water table from ground surface was measured with the help of measuring tape. Altitude is measured with the help of GPS. These water level data is converted to mean sea level referenced data by using altitude value. After getting the MSL referenced to water level data, water table contour map is prepared with the help of Arc GIS 9.1 (Fig. 5). The pre monsoon water table contour varies between -45 m (bmsl) to 75 m (AMSL). Shallow water tables are found in eastern part; whereas deeper water values are found in the southern and northern part (Fig. 5).

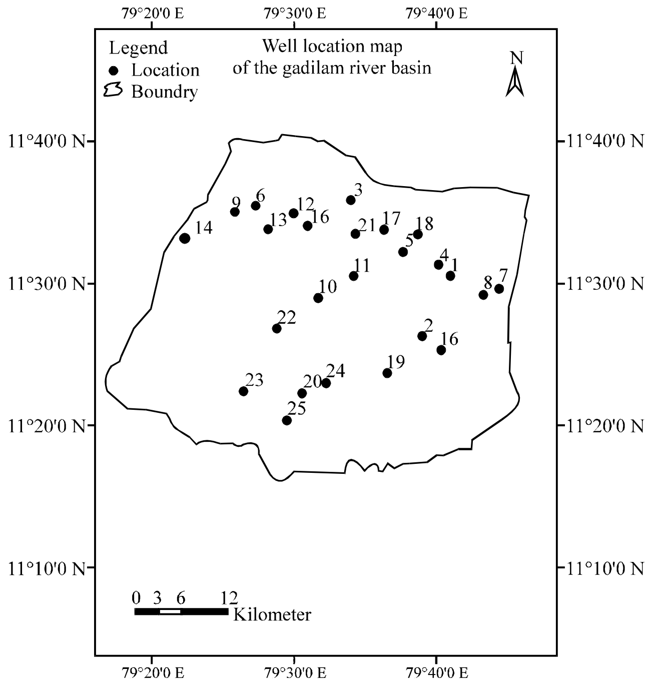

Fig. 4: Well location map of the study

Table 1: Water table data in the sedimentary part of Gadilam river basin

Well. No.	Location	Pre-Monsoon	Post-Monsoon	Water table fluctuations
1	Meenakshipettai	26.40	17.58	8.82
2	Krishnankuppam	34.66	30.56	4.10
3	Kullanchavadi	17.83	12.21	5.68
4	Sathankuppam	24.35	22.56	1.79
5	Naduveerapattu	21.30	12.40	8.90
6	Ramapuram	26.56	15.38	11.20
7	Kannarapettai	8.91	2.67	6.24
8	Valichothanaipalaya	22.59	13.21	9.38
9	Vadalur	32.18	27.67	4.51
10	Azhagappasamudram	72.48	47.51	25.00
11	Pathrakottai	54.52	43.59	10.90
12	Semakottai	28.27	24.12	4.15
13	Thiruvamur	23.41	20.72	2.69
14	Abathanapuram	39.51	25.32	14.20
15	Anguchettipalayam	20.12	18.32	1.80
16	Poongunam	17.12	15.69	1.43
17	Muthukrishnapuram	4.31	2.24	2.07
18	Thotti	10.12	8.54	1.58
19	Annadanapettai	33.41	11.19	22.20
20	Chittankuppam	68.51	25.32	43.20
21	Sathipattu	11.26	8.90	2.36
22	Muthandikuppam	76.44	71.36	5.08
23	Melakuppam	58.05	49.56	8.49
24	N of Seplanatham	-46.00	-52.00	-6.00
25	N of NLC II mine	-12.00	-20.00	-8.00

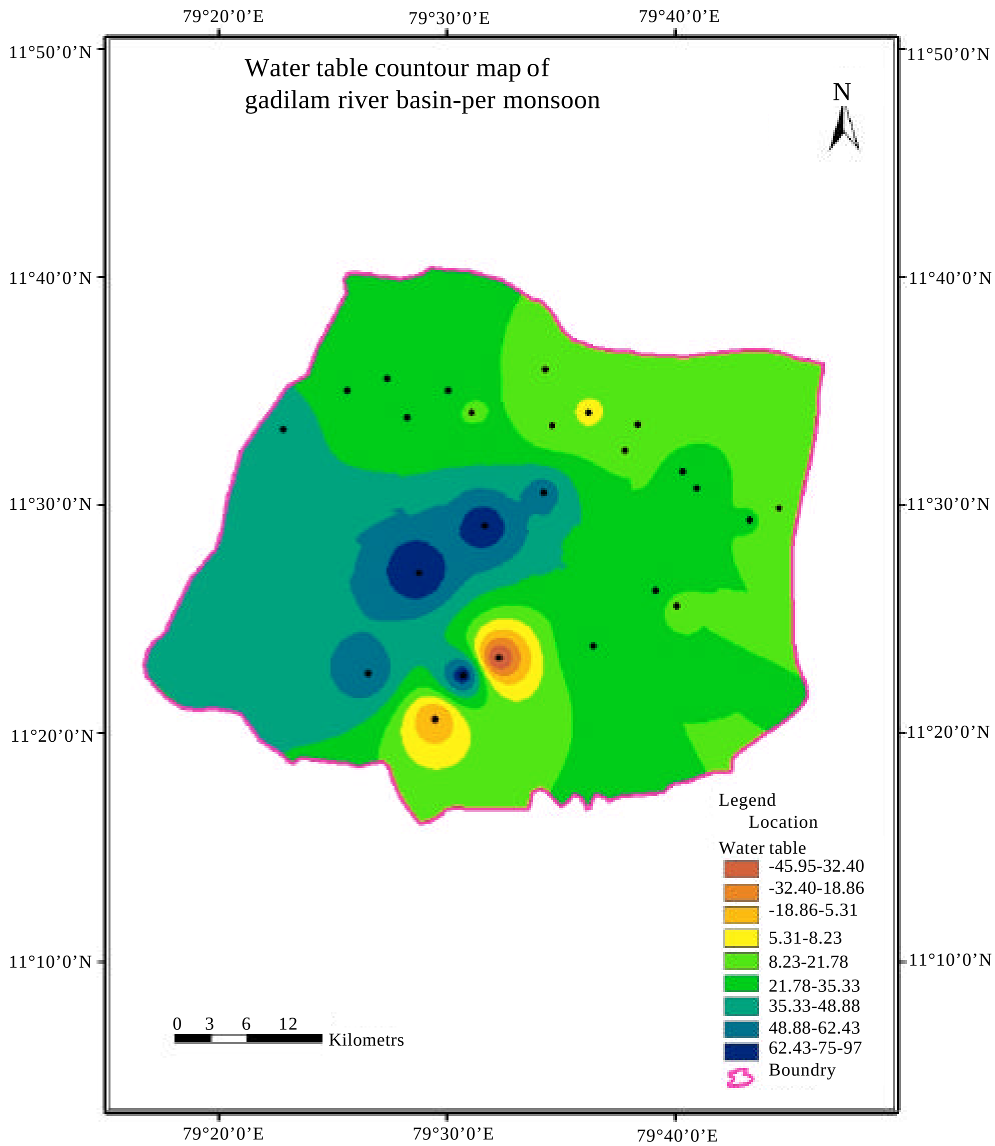

Fig. 5: Water Table contour map of the study area (pre-monsoon)

Average water table depth from ground is 60 m is water in tertiaring formation were found to be in confined conditions a results they were at deeper depth and found to be occurring below.

Post monsoon water table: Post monsoon water level data was collected for January 2008. Depth to water table is measured from the respective observation wells. Similar procedures were adopted as similar to pre monsoon. Post monsoon water table map was carried out using Arc GIS for post monsoon water table contours were prepared (Fig. 6). Post monsoon water table varies in the range of 60 m (BMSL) to 70 m (AMSL). Similar to pre monsoon water level eastern part shows shallow water table where as, southern part shows deeper water table (Fig. 6). Reason is

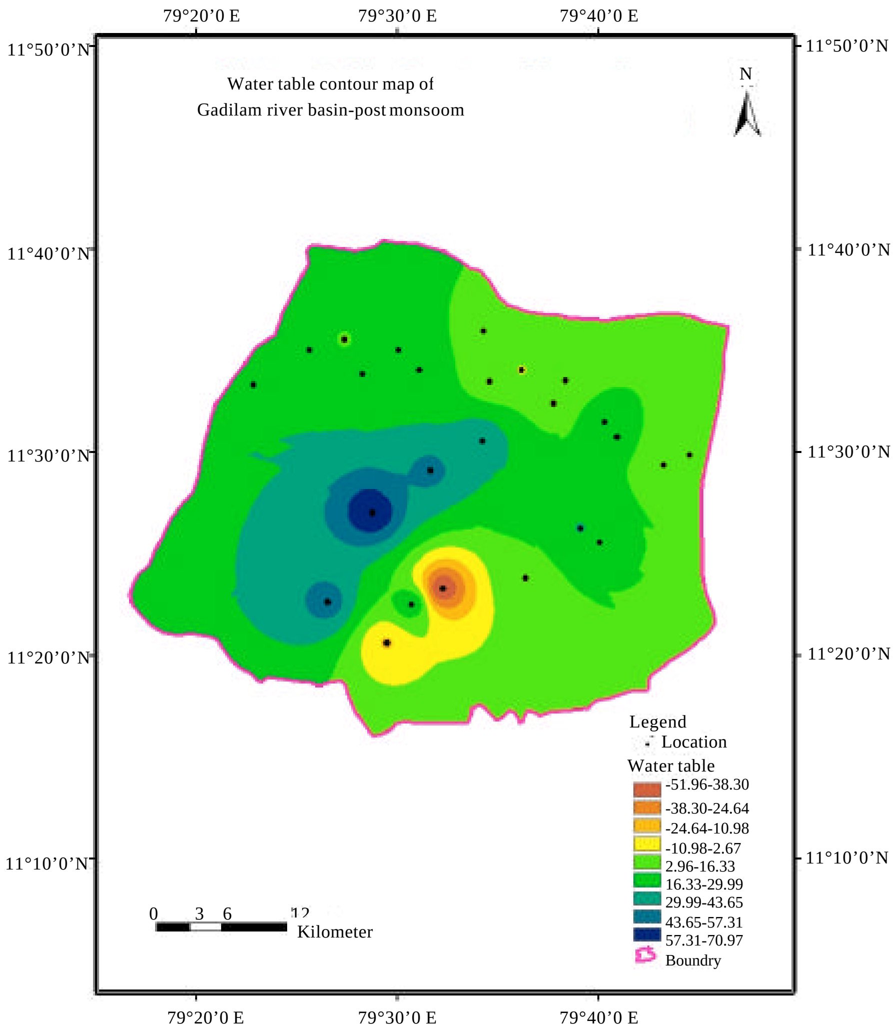

Fig. 6: Water Table contour map of the study area (post-monsoon)

water in recent formation was found to be in unconfined condition as a result they were at shallow depth as they are found to be in a plain country. Overall average water table depth from ground is 60 m.

Water table fluctuation: Water table fluctuations map was prepared using the difference in level of pre and post monsoon water level data. Water level fluctuation map is prepared using spatial analysis of Arc GIS software (Fig. 7). Water table fluctuation is one of the important map to study the movement of groundwater. From the above map we could find the cone of depression or abstraction is more in south central part of the study area due to abstraction in Neyveli mines. As a result ground water flow is towards the Neyveli mines (Fig. 7). From the fluctuation map, it is also found that maximum recharge in water level is in the Northern and Southern part of the study area in between vellar and Neyveli mines with less

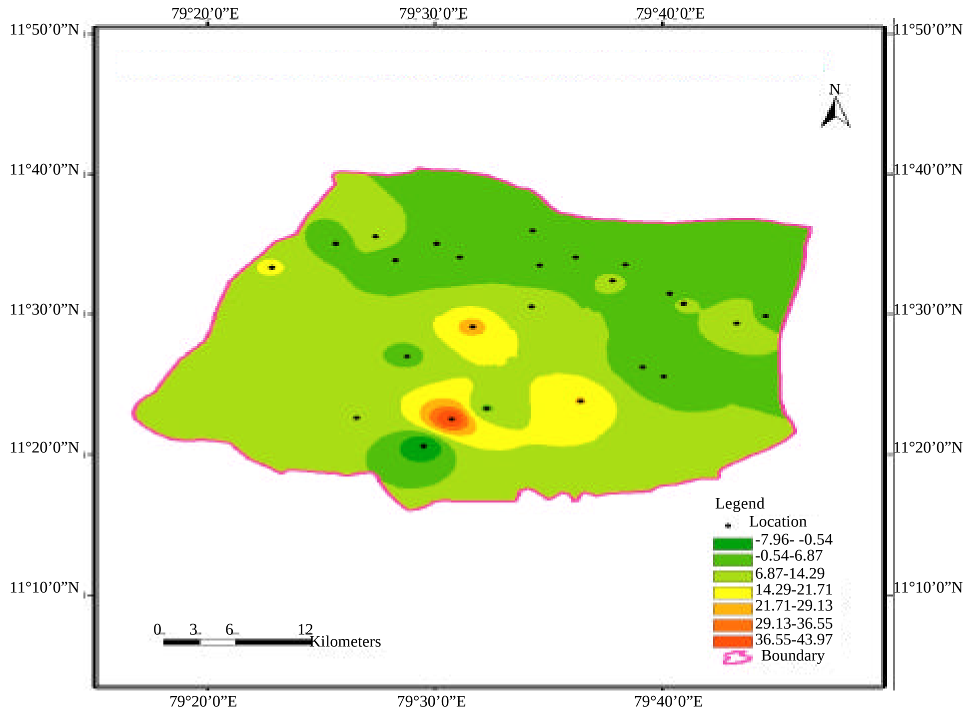

Fig. 7: Water level fluctuation map of the study are

than 6 mAMSL of water level. Northeastern and Northern part of the study area shows minimum rise in water level with less than -0.5 m (Fig. 7).

Generally water table has a configuration similar to that of land surface; however, depth to water levels are deeper in uplands (recharge areas) rather than in the area adjacent to the river valley and discharge areas.

Water level data of pre and post monsoon season was collected and water table contour map is prepared with the help of Arc GIS 9.1 as shown in Fig. 5 and 6. Shallow water tables are found in eastern part, where as deeper water tables are found in the southern and central part. Average water table depth from ground is 60 m below the ground level. Post monsoon water table varies I the range of-51 m (BMSL) to 70 m (AMSL). Even during post monsoon water level in southern part shows deeper water table where as, central and western part shows elevated water table (Fig. 6). In post monsoon period it is found that maximum recharge in deeper water level is found in the central and southern part of the study area. North-eastern and northern part of the study area shows minimum rise of water level of less than 6 m. As they were found in plain country and the reason is water in recent formation were to be under unconfined condition (Fig. 2 and 6). From the above study it is clear that for ground water fluctuation it is controlled by terrain morphology, under lying formation and the quantum of groundwater abstraction. An important finding of the above study is ground water movement/flow is toward Neyveli mines where cone of depression was created due to huge abstraction to depressurize the aquifer. Maximum fluctuation of 40 m is found within 6 months to confirm the recovery after monsoon season (Fig. 5-7). So, it is very clear apart from periodic recovery of deep bore wells of confining formation interaction between the connate water and naturally recharged rain water cannot be ruled out.

In the study area pediments occupies the north western and south eastern part (Fig. 3). Bore wells located in pediments have deep water table when compared to those in buried pediments. Ground water prospects will be found to be good in buried pediments because tube wells located in buried pediments have shallow water table in the east (Fig. 3, 5 and 7), when compared to pediments as the recharge of ground water is found to be high through friable and mottled sandstone. Above formations were found to be in confined conditions.

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