As mentioned in the preceding issue of 'The Eastern Ghats', it was decided to bring out the Volume 10, No. 2, 2004 also on the theme 'Hydrology and Meteorology' in an attempt to maintain continuity and mainly to provide inputs to the noticeable data gap pertaining to the ecologically sensitive area of the Eastern Ghats.

We wish to record our thanks to the Scientists from the National Geophysical Research Institute (NGRI), Hyderabad and the Department of Geology & Geo-Engineering Sciences, Andhra University for contributing their articles.

We have also selected three abstracts and one news item that we found relevant to our concern in the said eco-region. We would have liked to include some more abstracts and news items that were collected but the number of pages available for the issue restricted us. These references could be made available on receiving indent from our readers and also included in our Bibliographic database that is connected to our websites.

We are pleased to avail this opportunity to confirm that in addition to the website: www.envis-eptri.org we are available on http://envis-eptri.ap.nic.in. we have established cross link with the website of the Andhra Pradesh Pollution Control Board (http://www.appcb.org) in addition to the websites of the ICICI Virtual Park, Osmania University and the National Institute of Agricultural Extension Management (MANAGE).

ENVIS Coordinator

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**Contents**

1. Foreword ........................................................................... 1

2. Natural recharge rates in Khondalites/Charnockites, Basalt, Sandstone and Alluvium Formations of East Godavari district, Andhra Pradesh using injected Tritium tracer .............................................. 2

3. Abstracts ........................................................................... 8

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ENVIRONMENT PROTECTION TRAINING & RESEARCH INSTITUTE (EPTRI), HYDERABAD
Natural recharge rates in Khondalites/Charnockites, Basalt, Sandstone and Alluvium Formations of East Godavari District, Andhra Pradesh using injected Tritium tracer

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National Geophysical Research Institute, Hyderabad-500007, India

Introduction

The increasing demands for the development of groundwater resources for agricultural, industrial and domestic sectors necessitates proper water resources assessment and management. Improper management of ground water resources can lead to various problems such as higher pumping cost, reduction in yield, failure of wells, sea water intrusion to fresh water aquifers in coastal regions and land subsidence. For proper assessment of ground water resources and ground water budgeting, one of the key hydrogeological parameters is natural recharge / annual ground water replenishment rate.

The two principal types of natural recharge to ground water are direct / primary and indirect / secondary. The direct recharge results from vertical percolation of precipitation through soil and unsaturated zone. The indirect recharge results from percolation through beds of surface water bodies such as tanks, ponds, lakes, streams, canals, etc. The principal replenishment to ground water resources on a regional scale is by direct recharge.

We present in this paper the results of measurements of natural recharge rate (direct) due to 1997 monsoon precipitation evaluated using tritium tracer techniques in four different geological terrain of East Godavari district, Andhra Pradesh, India.

Study area and its characteristics

Natural recharge rate due to 1997 monsoon precipitation was measured in two areas, one located near Rajahmundry town and the other in Suddagedda watershed north of Kakinada town (Fig.1). Both these areas are located in Godavari basin agro-climatic zone (Zone 3) as classified by India Meteorological Department (Chowdhury et.al. 1992). The study areas are characterized by humid climate with severe summer and seasonal rainfall. The normal annual rainfall in the study areas is 1050 mm and occurs due to both south-west (June-Sept.) and northeast (Oct. – Dec.) monsoons. Storms and depressions originating in the Bay of Bengal during the post-monsoon period cross the coast causing widespread heavy rains and strong winds. Paddy, banana, sugarcane are the main crop types grown in these areas (Raju et. al. 1982).

Rajahmundry area

Physiographically the study area near Rajahmundry is located in an upland area and is flat in nature. The elevation of ground varies from 30 to 76 m above mean sea level and slopes in NNW-SSE direction (Raju et.al. 1982). The uplands partially merge with deltaic plain in the south. The main drainage channel, the Godavari River which is about 12 kms to the west of the study area flows in southern direction. The study area is underlain by Tirupati sandstone (upper Jurassic), Deccan trap with inter-trappeans (Eocene?), and Rajahmundry sandstone (Upper Miocene). The sandstone area is covered by red soils (Sandy loam to loam) and traps area by black soils (clay loam to clay). The soil thickness varies from 1.0 m to 3.0 m. The average annual rainfall recorded during 1997 was 1003 mm.

Suddagedda watershed

Physiographically the Suddagedda watershed drained by Suddagedda stream is partly in Deltaic Plains in the south and partly in an upland terrain in the north. The northern side has a series of hill ranges, which forms a part of eastern ghats. The major rock types are Khondalites/charnokites (Archaean) in the northern part and alluvium (recent) in the southern apart. Small area in the southern part is also underlain by basalt (deccan trap) and tirupati sandstone. The alluvium deposit comprise clay, sand, gravel and pebbles of various thickness. The soils of the study area are sandy loam, clayey loam to clay type. Ground water in the study area occurs under water table and semi confined condition. The average annual rainfall recorded during 1997 was 967 mm.

We present in this paper the results of measurements of natural recharge rate (direct) due to 1997 monsoon precipitation evaluated using tritium tracer techniques in four different geological terrain of East Godavari district, Andhra Pradesh, India.

Experimental technique

Principle and methodology

Tritium, having a Half-life of 12.43 years is commonly used as an artificial tracer in hydrogeological studies. The advantage is that the tritiated water molecule, HTO, does not behave differently from the other water molecules in the ground water cycle. The health hazard in handling tritium is negligible because of its emission of soft beta particles having maximum energies of only 18 KeV.

The tritium injection method of estimating natural recharge (direct) is based on the assumption that soil moisture moves downward in discrete layers. Any fresh layer of water added near the surface, due to precipitation would percolate by pushing an equal amount of water beneath it further down, and so on, such that the moisture of the last layer in the unsaturated zone is added to the ground water. This concept of water movement through soils, termed the piston-flow model has been developed by Zimmermann et.al. (1967) and Munnich (1968). In this technique, the moisture at certain depth in the soil profile is tagged with tritiated water. The tracer moves downwards along with the infiltrating moisture due to subsequent precipitation. A soil core from the tracer injected site is collected after a chosen interval of time and the moisture content and tracer concentration are measured for various depth intervals. The peak in its concentration distribution indicates the displaced position of the tracer. Moisture content of the soil column between the...
...tron values also adds to the scatter of data. The cumulative effect of both static and dynamic nature, the experimental error in estimation and local hydrogeological conditions. In addition to these natural factors (evapotranspiration), soil permeability, amount and intensity of rainfall at a site is controlled by many factors such as temperature (demands of large spatial variation within each geological formation. The recharge rate stations in this area during 1997. Natural recharge rates measured indicate Suddagedda watershed are 73.8 mm/yr and 101.0 mm/yr respectively for the average seasonal rainfall of 863 mm recorded from basalt formations in Rajahmundry area are 135.8 mm/yr and 90.5 mm/yr respectively. The mean natural recharge values, which give rise to variability, the mean recharge computed in different geological formations was still used for estimating annual replenishment to groundwater resources for the district. The inputs to the phreatic aquifers of Khondalites/charnockites, aluvium, sandstone and basalt are calculated as 398 million cubic meters (MCM), 434 MCM, 109 MCM and 29 MCM respectively. The total replenishable ground water potential of the district is calculated as 970 MCM for the rainfall of 850 mm for the 1997 monsoon precipitation in the study area. It can be computed as 1300 MCM for the average annual rainfall of 1140 mm for the district.

CONCLUSIONS / OBSERVATIONS

◆ Tritium tracer studies carried out in Rajahmundry area and Suddagedda watershed in East Godavari district gave a mean natural recharge rate of 135.8 mm/yr in sandstone terrain, 90.5 mm/yr in basalt terrain, 73.8 mm/yr in khondalites and charnockites terrain and 101.0 mm/yr in alluvium formations for the average seasonal rainfall of 850 mm during 1997. The annual recharge to the phreatic aquifers of this district is computed as 1300 MCM or 120.0 mm/yr for the average annual rainfall of 1140 mm.

◆ Natural recharge studies carried out in several areas of Andhra Pradesh State indicate that mean natural recharge rate in Khondalites/Charnockites/granite gneiss is 8.0 % and in proterozoic sediments, it is 10.4 % of the rainfall.

◆ The recharge measurements can form a primary database for artificial recharge programs, which would be needed for meeting the increasing demand for ground water by farmers of the semi arid tropical region of Andhra Pradesh.

ACKNOWLEDGEMENTS

The authors are thankful to the Director, NGRI for giving permission to present and publish this paper. This work was carried out for the project “Natural and Artificial recharge studies sponsored by Rajiv Gandhi National Drinking Water Mission, Ministry of Rural Development, Government of India. We are grateful to officials of RGNDWM for their support.
REFERENCES


Table – 1
Results of Natural Recharge Measurements in East Godavari district

<table>
<thead>
<tr>
<th>S.No</th>
<th>Site Name</th>
<th>Volume Moisture (%)</th>
<th>Displacement of tracer peak (cm)</th>
<th>Natural recharge computed (mm/y)</th>
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<td>1</td>
<td>Rajahmundry</td>
<td>20.9</td>
<td>95.0</td>
<td>198.7</td>
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<tr>
<td>2</td>
<td>Lalacheruvu</td>
<td>11.1</td>
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<td>150.3</td>
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<td>3</td>
<td>Srirampuram</td>
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<td>19.0</td>
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<td>Radhapalli</td>
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<td>10.2</td>
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<td>7</td>
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<td>82.7</td>
<td>105.4</td>
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<td>17.4</td>
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<td>Nandarada</td>
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<td>12</td>
<td>Nidigatla</td>
<td>40.1</td>
<td>65.0</td>
<td>260.8</td>
</tr>
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</table>

Depth of Collection: 2.5 m in 10 cm section

(2) Suddagadda Watershed (200 sq.km.)
Soil type: Loam to Clay loam Total Rainfall (1997): 970 mm
Av. Seasonal Rainfall (1997): 850 mm

- Mean recharge in Basalt (8 Sites) = 90.5 mm/yr
- Mean recharge in Sandstone (12 Sites) = 135.8 mm/yr
- Depth of Tritium Injection: 60 cm
- Injection: June, 1997
- Soil Core Collection: December, 1997
A case study of the scenario of water resources in Visakhapatnam urban area with reference to Eastern Ghats

P. Jagadeeswara Rao
Department of Geo-Engineering, Andhra University, Visakhapatnam-530 003

Visakhapatnam District has a vast stretch of seacoast and high altitude hilly areas. It has a geographical area of 11,161 sq.km occupying nearly 4.1% of the total land area of Andhra Pradesh state. As per the latest Census 2001 the district has a population of about 37.89 lakhs. The district is famous for steel and various other industries, often it is called as Visalkha Steel City.

The normal rainfall of the area is around 1202 mm. The rainfall precipitation varies from hills to plains and coastal plains. The district has four major rivers namely, Thandava, Varaha, Sarada and Gosthani. Thandava and Gosthani rivers are the geographical boundaries between the districts of East Godavari and Vizianagaram. Besides these rivers, there are small rivulets which flow as individual rivers into the Bay of Bengal.

Several hydraulic, infiltration wells and infiltration galleries were constructed with a view to supply water from these rivers to different municipalities within the district. Population load and industrial growth have put a lot of pressure on water resources, hence, water scarcity occurred.

Further, these rivers were perennial in earlier times but now they became non-perennial. It implies that this region is receiving less amount of rainfall year after year while the demand for water is increasing gradually.

The district has a forest cover of about 42.15%, which is slightly on the higher side as per the forest cover requirements. The landuse under irrigation and barren lands accounts for 30.23% and 11.78% respectively. Physiographically, the area comes under the Eastern Ghats. The rock types observed as khondalite, charnockite, granite gneiss and quartzite, etc. Khondalite is occurring as a major rock type and is subject to intense weathering. Charnockite and quartzite occur as later intrusives into the country rock. The general strike direction is northeast-southwest (Krishnan 1982) and thus coincides with the general strike of Eastern Ghats. Local variations in structural trends from northeast-southwest through eastwest to northwest-southeast are noticed (Sriramadas 1964).

Ground water occurs under confined and semi-confined conditions. Now-a-days, ground water became a major source for drinking and irrigation activities in the area. Due to excess draft, particularly in urban areas, most of the wells are getting dry, which leads to seawater intrusion.

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EPTRI - ENVIS Newsletter
Vol. 10 No.2, 2004

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![Geological Map of East Godavari District](image)

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Mean recharge for Granite (4 sites) = 73.8 mm/y
Mean Recharge for Alluvium (8 sites) = 101.0 mm/y
Depth of tritium Injection = 60 cm
Injection: June, 1997
Soil profile collection: December, 1997
Depth of Collection: 2.5 mts in 10 cm section.

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<table>
<thead>
<tr>
<th>Site No.</th>
<th>Site Name</th>
<th>Volume Moisture (%)</th>
<th>Displacement of tracer peak (cm)</th>
<th>Natural Recharge Computed (mm/y)</th>
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<td>19.6</td>
<td>56.5</td>
<td>110.8</td>
</tr>
<tr>
<td>2</td>
<td>Omangi</td>
<td>48.5</td>
<td>17.1</td>
<td>82.9</td>
</tr>
<tr>
<td>3</td>
<td>Sarabhavaram</td>
<td>52.5</td>
<td>6.4</td>
<td>33.6</td>
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<tr>
<td>4</td>
<td>Vannepudi</td>
<td>26.1</td>
<td>26.0</td>
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<tr>
<td></td>
<td><strong>Granite</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Lampakalava</td>
<td>32.4</td>
<td>22.3</td>
<td>72.4</td>
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<td>2</td>
<td>Peddipalem</td>
<td>51.4</td>
<td>13.6</td>
<td>69.9</td>
</tr>
<tr>
<td>3</td>
<td>Chunta Sankarlapudi</td>
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<td>42.5</td>
<td>195.0</td>
</tr>
<tr>
<td>4</td>
<td>Pratipada-Annavaram</td>
<td>47.5</td>
<td>43.6</td>
<td>207.1</td>
</tr>
<tr>
<td>5</td>
<td>Timmapuram-Veldurtri</td>
<td>39.8</td>
<td>17.9</td>
<td>71.2</td>
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<tr>
<td>6</td>
<td>Near Vannepudi</td>
<td>34.2</td>
<td>20.5</td>
<td>70.1</td>
</tr>
<tr>
<td>7</td>
<td>Near Golaprole</td>
<td>35.5</td>
<td>19.4</td>
<td>68.9</td>
</tr>
<tr>
<td>8</td>
<td>Gollapule-Raporti</td>
<td>38.6</td>
<td>13.9</td>
<td>53.6</td>
</tr>
<tr>
<td></td>
<td><strong>Alluvium</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
into certain areas along the seacoast. Jagannadha Sarma and Krishnaiah (1976) observed abnormal saline content in the wells in Kaniti-Paravada area. This is ascribed to seawater contamination due to low-level conditions in the area. Industrial liquid effluents and municipal sewage further deteriorated the quality of ground water in the district. The ground water regime of Visakhapatnam was categorized into three zones, viz. weathered zone, backwater zone and industrial zone. Water samples from Hindustan Polymers, Hindustan Zinc Limited and Urban areas were covered. The study revealed that the intensity of pollution in ground water increased from the period 1975 to 1981. This is due to rapid growth of urban and industrial activity in the Visakhapatnam area (Subba Rao and Krishna Rao 1990). Most of the rivulets have turned into unlined municipal sewage drains. These have become major sources of ground water pollution in the vicinity of these major conduits (lineaments).

The water table fluctuation in the year 2003 is between 3.28 m bgl (below ground level) to 8.22 m bgl in the district. A continuous monitoring can give us an idea regarding ground water flows and usage pattern in the district. Keeping in view the increasing demand on ground water, permanent piezometric wells were already established to monitor regular water levels in the district. The water table fluctuation varies from year to year. This relates to the amount of rainfall precipitation in the area, net recharge and draft from the ground water. The rainfall precipitation versus water table fluctuation is given in Table 1. During the year 2002 the area has received 700 mm rainfall which is below normal. Due to less amount of rainfall, this year was considered as a year of severe drought.

Table 1. Rainfall precipitation versus water table fluctuation for the years 2001 to 2004 (upto January) (Source: A.P. Ground Water Department)

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Fluctuation Average annual Rainfall (District)</th>
<th>Hilly terrain (11 stations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>May</td>
<td>6.55 2.76</td>
<td>3.79</td>
</tr>
<tr>
<td>2002</td>
<td>May</td>
<td>6.28 5.9</td>
<td>0.38</td>
</tr>
<tr>
<td>2003</td>
<td>May</td>
<td>8.22 3.28</td>
<td>4.94</td>
</tr>
</tbody>
</table>

The WHO (1971) reported that nearly 80% of the diseases in the world population are due to consumption of polluted water. The quality of ground water is incipient. The water contains a high amount of hardness i.e., 1200 – 2000 ppm in the area. In certain areas fluoride ranges from 0.5 to 1.5 ppm and more is occurring in excess amount in Mindi area. Hence, people are severely affected due to fluoride levels in ground water. The concentration of fluoride in ground water is not uniform and this is due to variations in the source of fluoride mineral in the area (Rao et al. 1998). In Paderu, the ground water contains higher amounts of iron and people in this area use stream water for their regular activities.

In this district, Visakhapatnam urban area has a population of 9,69,608. The supply of municipal water from different reservoirs accounts for 43.6 MGD. The municipality has 3,644 hand bores, most of them are in slum areas. It is estimated that each bore well yields 3600 liters/day. The municipality has given 40,000 tap connections to different houses, business establishments, hospitals, restaurants, etc. In addition to the aforementioned sources, 46 pilot water schemes supplying 1104000 liters of water every day. In this area, nearly 50,000 bore wells and 5,000 dug wells with an average yield of 3000 and 2000 liters respectively also exist to cater the needs of urban dwellers.

   Population of Visakhapatnam Urban area for the year 2003: 10,34,882
   Water requirement as per WHO standard per head/day: 140 liters

Total requirement for urbanites/day: 1034882 x 140 = 144883480 liters (144.883 MLD)

II. Water availability/supply
   Municipal source (Reservoirs)
   Raivada : 20.00 MGD
   Meghadrigedda : 10.00 MGD
   Thripudi : 9.00 MGD
   Gosthani : 4.20 MGD
   Mudasarlova : 0.40 MGD
   Total = 43.60 MGD : 198205600 liters (198.2056 MLD)
   (Source: Visakhapatnam Municipal Corporation)

III. Industrial requirement from reservoir water: 16 MGD (72.736 MLD): (198.2056-72.736 = 125.4696 MLD)

IV. 46 pilot water schemes
   (based on ground water) : 1104000 liters (1.104 MLD)
   (8 hours/day @ 3000 liters/hour)

V. 3644 municipal bore wells : 13118400 liters (13.2184 MLD)
   (@ 15 liters/2 minutes for 8 hours)

VI. 50,000 individual bore wells
   (assumed 3000 liters from each bore) : 150000000 liters (150.00 MLD)

VII. 5000 individual dug wells
   (assumed 2000 liters from each well) : 10000000 liters (10.0 MLD)

VIII. Available resource : 299.792 (MLD)

IX. Domestic & Industrial requirements : 217.619 (MLD)

X. Surplus water resources available in the year 2004 (March): 82.173 (MLD)

The rapid urbanization and industrialization in Visakhapatnam area rendered severe scarcity of water resources, particularly ground water. With this result, ground water mining takes place at places (Venkateswara Rao 2000). It reveals that the areas may lose permanently the natural process of infiltration affecting the water table. If this happens, it is an irrevocable loss to the urbanites. This is due to covering of the earth surface with different constructions. This problem is more severe in Visakhapatnam old city. It is fortunate that there are some vacant sites left in the premises of Andhra University, Port-Trust and Visakhapatnam Railway area. These areas are places for recharge of ground water to a limited extent.
During the year 2003, the area has received excess amount of rainfall. With this condition, the reservoirs have received sufficient storage and recharging of water table has taken place to some extent. With these reserves and surplus water resources, the summer season of the year 2004 may not pose acute shortage of water for domestic and industrial requirements.

Generally, if the area received normal rainfall, it may sustain water resources from surface and subsurface sources up to the month of March. Thereafter, gradual decrease takes place by the end of April. During this period, the demand on water requirement is more. To compensate this void, the only alternative to augment ground water is the adoption of artificial recharge and to bring the Godavari River water to cater the needs of domestic, industrial and irrigation requirements.

References:
Chief Planning Officer, Visakhapatnam.  
Jagannadha Sarma, V.V. and Krishnaiah, N.1976. Quality of ground

Groundwater Quality in a Tribal Region of Eastern Ghats

N. Subba Rao and Srinivasa Rao, G. 
Department of Geology, Andhra University, Visakhapatnam – 530 003

Tribals living in the remote and inaccessible areas, are the most deprived sections in the society. Their living conditions, especially related to the health are very poor. The tribal population of 0.2 million of Visakhapatnam district, Andhra Pradesh is not exception. Groundwater is the potential source of drinking water in the region. Hence the quality of groundwater plays a vital role in the health conditions of the people. In this article, geo-environmental control on the groundwater quality with reference to Ca$^{2+}$ and F$^{-}$ ions in tribal areas of Araku, Paderu, Dharkonda, Chintapalli and Koyyuru in Visakhapatnam is described.

Major geological formations in the region belong to Khondalite suite of rocks and the associated intrusive bodies. Thickness of the weathered zone varies from 10 – 30 m. Groundwater exists either in the weathered zone or in the fractured zone. The pre-monsoon (May) water levels vary from 4 – 19 m below ground level (bgl) and those of the post monsoon (November) are in the range of 2 to 12 m bgl. Well yields lie in between 30 – 120 m$^3$/Day.

Groundwater are neutral to alkaline (pH 6.7 to 8.2) with a total alkalinity (TA) of 20 – 197 mg/l, fresh water type (total dissolved solids, TDS < 1000mg/l) and of soft to hard (total hardness, the TH 25 to 200 mg/l). As the concentration of TDS < 500 mg /l (mean 260 mg/l) which suggests the low levels in the concentrations of cations (Ca$^{2+}$,Mg$^{2+}$, Na$^{+}$ and K$^{+}$) and anions (HCO$^{-}_3$, Cl$^-$, SO$^{2-}_4$ and F$^{-}$). The concentrations (mg/l) of Ca$^{2+}$, Mg$^{2+}$, Na$^{+}$, K$^{+}$, HCO$^{-}_3$, Cl$^-$, SO$^{2-}_4$ and F$^{-}$ are in the range of 5 – 46, 2 – 16, 9 – 50, 1 to 5, 25 to 240, 10 to 85, 2 to 8 and 0.1 to 0.4 with a mean of 22.58, 7.81,17.25,2.04, 104.80, 25.40, 3.80 and 0.18, respectively. Relation of TA with TH suggests that the groundwater belong to non-carbonate hardness type due to the dominance of Cl$^-$ and SO$^{2-}_4$ ions.

From the health point of view, the concentrations of TDS, TH, Ca$^{2+}$, Mg$^{2+}$, Cl$^-$, SO$^{2-}_4$ and F$^{-}$ ions are far below the recommended limits (i.e. 500, 300, 75, 30, 250 and 0.6 mg/l) for drinking water (ISI, 1983). Low levels of these ions cause dental caries, osteoporosis, and gastro-intestinal irritation. Gastro-intestinal irritation is common among the adults in the region, showing that the disease is developed over a long time. Dental caries is more frequent among the children in the region. Osteoporosis, a deficiency disease of the bones generally common among the old persons, found to be affecting even the middle aged people in the region.

The low concentrations of various chemical ions in the groundwater in the region appears to be caused by geo-environmental phenomena. One of the prime factors is the soil-erosion. Generally, decreased rate chemical weathering, due to high relief (300 to 1700m AMSL) of the regions supports less enrichment of mineral contents in the groundwater. High rainfall (1100 to 1900 mm) associated with the steep slopes (<50°) in the region leads to a rapid fluxing of water and hence short – contract time with the soils, resulting in less mineral content of run-off water (Drever, 1988). Another factor is the podu (shifting) cultivation, which is common and server in the region, and a major cause of soil-erosion as well as deforestation. Thus, the highly erodable region has greater loss of top soil, which generally contains valuable salts. As a result, the chemical constituents, including Ca$^{2+}$ and F$^{-}$ ions, form the soil are not leached properly into the groundwater.

Climate is another important factor to control the concentrations of chemical ions in the groundwater. The role of climate is discussed, especially, with reference to the Ca$^{2+}$ and the F$^{-}$ ions in the region. Minerals,
such as calcite (CaCO$_3$) and Fluorite (CaF$_2$) have rather low values of their solubility products. Generally, the concentrations of Ca$^{2+}$ and F$^{-}$ ions in the groundwater rise to the higher levels, when the water is lost along with CO$_2$ due to precipitation of CaCO$_3$ and CaF$_2$, where the process of evaporation / evapo-transpiration is more active (Handa, 1975). As the sub-humid climate of the region leads to a fresh water exchange, the evaporation / evapo-transpiration process may not be very active. Hence, the groundwaters show low concentrations of Ca$^{2+}$ and F$^{-}$ ions.

The effect of climatic factor in this regard has also been assessed, adopting the equilibrium-thermodynamic approach, which is widely employed to verify whether the particular mineral species undergoes precipitation or dissolution. As per this approach, the activity values of all the groundwater samples suggest that the samples are under unsaturated zone with respect to the solid phases of CaCO$_3$ and CaF$_2$. It means that the CaCO$_3$ and CaF$_2$ ions are in the dissolved state at low concentrations, because of the sub-humid climate of the region. Therefore, they could not reach the higher levels in the groundwater.

The present study infers that the geo-environmental factors, such as climate, deforestation and soil-erosion, are the main reasons responsible for the low concentration of chemical ions, especially, Ca$^{2+}$ and F$^{-}$ ions in the groundwaters.

As the Ca$^{2+}$ and F$^{-}$ ions have a vital role in the human health, fluoridation of water supplies has been suggested as an immediate measure to maintain the optimum concentration of F$^{-}$. Afforestation of the podu-cultivated areas and management of the existing forests at the required density, which decreases the rapid soil erosion and water run off, is suggested as long term measure to increase the concentration of chemical ions in the groundwater. Awareness should be created among the tribal people to divert them from podu cultivation that causes ill health due to environmental degradation (deforestation) and also by encouraging arboriculture among them as alternative livelihood.

References


ISI (1983), Indian Standard Specifications for Drinking Water, IS : 10500

List of Meteorological Stations in the Eastern Ghats Region under the Andhra Pradesh Hydrology Project

<table>
<thead>
<tr>
<th>Name of Station</th>
<th>Mandal</th>
<th>District</th>
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Cont'd... p.11 & 12

Environmental flow and River protection for Salandi, Orissa, India

Dr. Bishnu Prasad Das
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Salandi, an east-flowing medium river in the state of Orissa, India with a basin area of 1500 sq. km. and arable land of 1,30,000 ha supports a population of 0.8 million primarily dependant on agriculture. The fertile lands are flood prone as the river in the coastal zone has a ridge profile and spills extensively in the lower 50 km reach because of the high monsoon rainfall (June-October) in the range of 1200 to 1500 mm.

The basin is also a drought prone because of erratic trend of monsoon in September-October. For stable agriculture through irrigation to 91,000 ha and protecting almost 70,000 ha of low land from flood, a dam intercepting 673 sq. km. of basin and a pickup barrage were built in 1970. The upper forested basin was contributing a peak flood of 6,000 m$^3$/sec, an average monsoon flow of 1,500-2,000 m$^3$/sec and non-monsoon flow of 100 m$^3$/sec which the dam totally abstracted for consumptive use through irrigation. As a consequence there has been no spill to the lower basin thereby denying inundation irrigation to 50,000 ha in the lower basin downstream of the command.

Considering that almost 1,000 sq. km. of command area is being fed by a basin of 673 sq. km. the average annual irrigation need of 58,000 ha is just met from the average monsoon yield of 61,000 ha. In the worst drought year of 1987 the basin yield was only 22,646 ha. With the monsoon flow below the dam drastically reducing to 200-300 m$^3$/sec, the non-monsoon flow dwindling to 5 m$^3$/sec, several pockets of wet land in the lower basin have dried up and can no longer sustain fish in particular and summer irrigation of cash crops and horticulture in general. The river below the dam has gone into distress as the channel has deteriorated to a 30-40 m. width and 3-4 m depth from the original bankful width and depth in the range 100-150 m and 6-10 m respectively. Consequently occasional spill up to a maximum of 500 m$^3$/sec causes overbank flooding. The dam is located 90 km upstream of the confluence of Salandi and Baitarani, a major deltaic river which spills a large 2000 km$^2$ area into the upstream tributary of the Ganges. The agricultural practices in the river basin and its drainages and people's participation are discussed and presented.

Water management through subsurface dams in the rapidly urbanising upper Swarnamukhi river basin, Chittoor district, Andhra Pradesh, India

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The Swarnamukhi River rises in the Panapakam extension forest at an elevation of 715m in Chittoor district, A.P, India and flows in Nellore district to finally join the Bay of Bengal. The upper Swarnamukhi basin within Chittoor district has a drainage area of 3,225 sq.km. The climate is hot and semiarid with annual rainfall showing a high spatial and temporal variation ranging from 332 to 2188 mm.

Sugarcane cultivation in the place of dry crops further led to stress on water availability in summer. The measure taken up to meet the water shortages includes large-scale pumping of deep groundwater and import of water from other river basins. This paper aims at achieving greater water security through construction of subsurface dams to prevent the large-scale flow of groundwater through the sandy/bouldery alluvium of the river.

Presentation of the Project (major findings) Problem Analysis:
Groundwater within sandy/bouldery alluvium underlying the Swarnamukhi River bed flows at a rate of around 100 metres a day as against a flow rate of a fraction of a metre a day within clay or rock surrounding it. Natural subsurface flow together with excessive pumping of groundwater through wells in the sandy alluvium may often result in drastic reduction of groundwater yields particularly during summer.

Using impervious puddle clay has evolved a labour-intensive and capital-saving method of constructing subsurface dams to obstruct flow through alluvium.

Discussion of the Results/Findings:
Instead of flowing downstream and getting lost into the sea, water arrested by a subsurface dam within sandy alluvium and boulders of a river remain in the upstream of the dam for a longer time. The fate of water so arrested can be as follows.

1) If information surrounding the sandy alluvium is impervious, the water remains in the upstream of the subsurface dam to raise the water table and make the river perennial for a longer period.
2) If a deep pore bore well is already located in the fractured zone receiving groundwater from the water arrested by a subsurface dam, there will be a substantial increase in its yield.
3) If no well is located in the fractured zones receiving groundwater from the arrested water, the benefits of the subsurface dams could not be appreciated.

Taken up for the recharge of shallow groundwater on a large scale to bring the ground water levels from the present 10-15 metres below ground level to 2-3 metres below ground level and thereby revitalize the large number of shallow dug wells, which have become dry owing to excessive pumping of groundwater through deep bore wells.

Conclusions and Achievements:
The water arrested and stored in the upstream of the subsurface dams across the Swarnamukhi River is estimated at 3 million cubic metres a year. The water so conserved is estimated to benefit around 42 thousand small and marginal farmers. Has been moving into certain deep fractured zones within hard rocks to recharge deep groundwater. These dams have helped the deep bore wells to give large yields throughout the year on a sustainable basis. In addition, construction of new bore wells piercing fractured zones getting recharged by water conserved by the subsurface dams could be taken up to achieve greater water security.

As the technology used for the construction of subsurface dams is essentially labour-oriented, the whole work has led to the creation of 180 thousand man-days of work.
Source: www.siwi.org/waterweek2003/workshop%204%20poster (20).htm

Hydrogeomorphological studies in the Trichirapalli Environ, Tamil Nadu, India using Remote Sensing Technology

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The growth of the population increases year by year more stress on agriculture sector for increasing the food grain production, which consequently increased deforestation and demand for more water. Trichirapalli environs, Tamil Nadu, are chronologically drought prone and faces acute water scarcity not only drinking purposes but also agriculture purposes.

In general, surface water are more polluted when compare to groundwater. Hence, groundwater serves as a very important source of water for various purposes not only urban development but also rural habitations improvements. In recent years extensive use of satellite remote sensing has made it easier to define the spatial distribution of its different groundwater potential zones based on the geomorphology and it is associated features (Prithvi Raju, 1980; Sankar et al., 1993). The interpretation of satellite data in conjunction with sufficient ground truth information makes it possible to identify and outline various ground features such as geological structures, geomorphic features and their hydraulic characters (Das et al., 1997), that may serve as direct or indirect indicators of the presence of groundwater (Ravindran and Jeyaram 1997).

Study Area:
The area under study Trichirapalli environs central part of Tamil Nadu State. It lies between north latitudes of 9°45’ to 11°15’ and east longitudes 78°15’ to 80°30’ and covers an area about 9000sqkm. The major river Cauvery is ephemeral nature through the area from east to
Denudational hills are marked by sharp to blunt crest lines with preparation of hydrogeomorphological maps, usually integrated with the remote sensing technology information for the preparation of hydrogeomorphological maps. The study area is plain but gently sloping towards the east and southeast. The elevation of the area is in general ranges from 300-500 m above MSL. Cauvery River and its tributaries as well as Amaravathi and Bhavani rivers drain the area. Groundwater occurs below water table conditions, especially in the weathered and fractured portions of the crystalline formations. The depth of groundwater table ranges from a few mts. to 30 mts. below ground level. In the sedimentary areas, groundwater occurs under semi-confined conditions, water level ranges from a few m to 20 m below ground level.

Drainage is mostly dendritic to sub-dendritic patterns controlled by fracture and joints are exists in the hard rock areas whereas sedimentary areas, parallel to sub parallel pattern is well developed in the east, northeast and southeastern part of the study area.

Data used:
IRS 1A LISS I (Path 24 and Row 61) imagery for visual interpretation. Survey of India toposheets Nos. 56J/9, 10, 11, 13, 14, 15, 12&16 and 58N/1, 2, 3, 4 and 80/1.

Methodology:
The IRS IA LISS I (false colour composite) have been visually interpreted by using standard interpretation keys such as colour, texture, pattern of drainage, shape and topography etc., to prepare geomorphological maps.

Results and Discussion:

Geologically, Trichirapalli environs falls between both hard crystalline and sedimentary formations. The hard rocks include hornblende biotite gneisses, charnockites, granitic gneisses and anorthosites of Archaean age. The pegmatite/quartzite’s vein is present in the intrusive bodies, which act as good groundwater barriers to store groundwater (Karanth et al 1992; Scuba Rao, 1992). A number of structural features like antiformal folds conform folds and overturned folds are found. The sedimentary formations beds overlie the crystalline formations in the areas of northeastern, eastern and southeastern parts. Sedimentary rocks comprises of laterite uplands, sandstone (Tertiary age), an isolated pocket of dury crust (Cretaceous formations) and patches of Gondwana formations. The boundary between crystalline and sedimentary units lies east of Senkipatti and north of Alathur. The major rock types encountered in the sedimentary areas sandstone, clay, laterites, sands; shale, kankar, limestone and fossiliferous limestone etc.

Well Inventory:
Well inventory was conducted on open well by observing the well cross sections and lithology of the various bore wells and dug wells information was collected from the well owners and drillers.

Geomorphological Studies:
The geological, structural, well inventory, hydrological data was integrated with the remote sensing technology information for the preparation of hydrogeomorphological maps.

Denudational hills and Residual hills:
Denudational hills are marked by sharp to blunt crest lines with rugged tops indicating that the surface runoff at the upper reaches of the hills has caused rill erosion. They are mostly exposed to the south to southwest. Denudational hills comprised of charnockites, hornblende biotite gneisses and anorthosites/quartzites. These are found to be south-central to southwest. The rugged topography of this region is due to the erosion of the denudational hills to the plain region, leaving the rock exposed. The ground water potential is moderate to poor.

Residual hills are the end products of the process of pediplanation, which reduces the original mountain masses into a series of scattered knolls standing on the pediplains (Thornbury, 1990). It is occurring as isolated patches are found at lower altitudes complex to the denudational hills. The shape of the residual hills, controlled by the different lithological composition, distribution and spacing of joints and fractures. In the imageries dark grey tone and coarse texture in black and white images and dark reddish colour in false color composite with radial drainages pattern (Gupta 1980).

Pediplain:
This is developed as a result of continuous processes of pedimentation. The altitudinal variations are relatively high for rolling plain and is about 5-10m. In this horizon are exists irregular dissected portions with a number of gully are present. The pediplains with sedimentary rocks exposures (upper Cretaceous formations) are to be found in the northeastern part of the area. This formed due to intensive weathering under semi-arid climatic conditions, representing final stage of the cyclic erosion (Knig, 1950 and Sparks, 1960). These are identified in the imageries grey tone on false colour composite (Ghose, 1993). Groundwater prospects in this unit good due to the moderate thickness (15-20m) weathering materials (Prakash and Mishra 1993).

Pediment Inselberg:
Pediment is isolated residual hillocks being remnants of weathering and denudation. Inselbergs are mostly barren, rocky, usually smooth and rounded small hills. This unit occurs in the northern, north-western and south-western parts of the study area. Mostly acts as runoff zones.

Allow Pediments:
This unit is basically pediments zone and various soil types cover over the pediment materials. This unit is very low weathering thickness of the materials upto 5m. These units characterized by very high runoff zone and poor groundwater recharge horizons. These units are found to be north, north-western, central, south and south-western parts of the study area.

Buried Pediments (medium):
This unit is moderately weathered with a thickness varies from 5-20m. The groundwater prospects in these units are moderately good. In this zone are found close of the cauvery river, south-central, southwest and southern parts of the study areas.

Buried Pediments (deep):
These units mainly due to highly weathering of the hornblende biotite gneisses under semi-arid climatic conditions. In this unit infiltration is moderately good. The thickness of weathered zone varies from 10-20m favours a good amount of water to circulate within this zone before reaching the deeper fracture zone. Groundwater potential zone is very good and this unit is suitable for dugwell, dugcumore wells and bore wells.
Flood Plain:
This is the youngest geological unit and including various landforms formed by fluvial action. This consists of sand, silt and clays and facilities channel bed infiltration. It is a highly permeable zone helping in partial bank recharge and subsurface flow groundwater occurs under semi-confined to perched water table conditions with shallow water levels. Groundwater prospects in flood plains are almost invariably found to be good (Sharma and Jugran 1992). In this units are exits all along the Cauvery river courses.

Deltaic Plain:
Deltaic plain is the major geomorphologic unit in the area and is under intensive cultivation. Within the deltaic plain some localized low lying areas, affected by water logged and soil salinity or alkalinity is found. The water logging and salinity problems may be due to the rising the water level, low lying topography and seepage from canals etc. this zone are found to be southeast, east, north-eastern parts if the study area.

Paleochannel:
Paleochannels or old river courses, buried by subsequent sedimentation are generally potential reservoirs for groundwater and hence useful for groundwater exploration. In addition to that, the Paleochannel identification useful in flood mitigation. In the identification of Paleochannel contrasting dark tones in a characteristics winding fashion in association with cropping pattern and linearly oriented vegetation.

Several Paleochannel are found to be deltaic region of the Cauvery river delta filled with sands. Soils in this region more moisture content as compared to the surrounding areas due to the groundwater flow zones. The paleochannels are observed mainly in the southeastern and eastern parts of the study area especially deltaic region of the Cauvery River. This area falls under the low-lying topography. The origin of the paleochannels may be due to the frequent changes in the river of Cauvery.

Groundwater prospects in buried channel are excellent because of hydrophilic nature of alluvial and colluvium deposits, retention of foot waters, location of contiguous to the river mainly responsible for recharge.

Lateritic uplands/ sandstone:
Lateritic uplands/ sandstone is developed over early pleistocene to recent age groups. The thickness varying from 10-15m and its characterized by moderate to good infiltration from rainfall and considerable water table fluctuations. Groundwater prospects in this unit are moderate to good in this zone because of the aquifer horizons sand.

Lineaments:
A lineament is defined as a large-scale linear feature, which expresses itself in terms of topography, which is itself, an expression of the underlying structural features. The groundwater point of view may include valleys controlled by faulting and jointing, hill ranges and ridges, displacements and abrupt truncation of rocks, straight streams and right angles off setting of stream courses etc., (Merh et al 1989 and Ramesh 1990). Lineaments are linear fractures commonly associated with dislocation and deformations. They provide the pathways for groundwater movement and are hydrogeologically very important (Sankar et al 1996). Lineaments are important in rocks where secondary permeability and porosity dominate and inter-granular characteristics combine secondary openings influencing weathering, soil water and groundwater movements. The fracture zone forms an interlaced network of high transmissivity and serves as groundwater conduits in massive rocks in inter-fracture areas. The lineament intersection areas are considered as good fracture areas. The lineament intersection areas are considered as good groundwater potential zones. Combination of fractures and topographically low grounds can also serve as the best aquifers horizons (Karanth 1989; Subba Rao 1992).

Finally Trichirapalli environs have been classified into three zones on the basis of their groundwater potential zones such as low, moderate and good after integrating well inventory, yield characteristics along with geological, geomorphological and hydrogeological information.

Summary and Conclusion:
Visual interpretation of IRS 1A satellite imageries provided information related to the geology, geomorphology and lineaments interpretation was helpful in knowing the nature and water potentiality of different geomorphic units. The composition of materials of landforms and there from inferred rechargeability and other hydrogeomorphic characteristics aid in identifying the groundwater potential zones.

Hydrogeomorphologically, the investigated areas occupied by denudational hills, residual hills, structural hills, pediments, pediplains, buried pediments shallow, medium, deep and deltaic plains. By studying the hydrogeomorphological conditions of the area, it is possible to decipher the groundwater potentiality. Most part of the area moderate to good, while rest of the area buried pediments medium, pediplains having moderate groundwater potential zones. In this area dug wells are recommended because, the water level drops during pre-monsoon period. Borewells are recommended the lineaments and intersections areas.

In the investigated area has undergone successive tectonic activities and is traversed by a number of lineaments whose analyses from IRS 1A satellite imageries interpretation provides useful information about tectonics and the structure of the area.

Source: www.gisdevelopment.net/application/nrm/water/overview/wato011.html

Cont’d from page 8
List of Meteorological Stations in the Eastern Ghats Region under the Andhra Pradesh Hydrology Project

<table>
<thead>
<tr>
<th>Name of Station</th>
<th>Mandal</th>
<th>District</th>
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Scientists review outcome of Climatic Predictions

Source: http://www.hindu.com/2004/03/16/stories/2004031603410500.html

KURNOOL, MARCH 15. Scientists from the Regional Agriculture Research Station, Nandyal, and ICRISAT reviewed the outcome of the advanced seasonal climatic predictions at a meeting in Nandyal on Monday.

The RARS and the ICRISAT jointly undertook the project by selecting three villages in Kurnool and two in Anantapur. Ten farmers were selected in each village. Under the project, the scientists predicted the rainfall taking into consideration the scientific data available and advised farmers to take up cropping pattern accordingly. The farmers were advised to sow long duration crops if the rainfall was spread over four months of the monsoon. In case of low rainfall and prolonged dry spells, short duration crops were taken up.

Last year, the project was implemented in Balapanur, U. Bollavaram and Orvakal of Kurnool district, Nusikottala and west Narsapur in Anantapur district. The scientists observed that the rainfall was on predicted lines in July and August while the dry spells were longer than predicted in September and October. Scientists who were associated with the project included T. Giridhar Krishna, senior scientist, RARS, Nandyal, Piara Singh, ICRISAT, S K. Krishnaiah, Agromet, Anantapur, Nageswara Rao, START-ICRISAT.

The Associate Director of Nandyal station, M R. Srinivasulu, presided over the meeting. The scientists felt that the narrow grid should be selected for prediction of climatic conditions. At present, Kurnool was considered the grid for predictions. Last year, the project officials considered the data of sea surface temperatures recorded by the International Climate Research Station, New York. Instead, the data recorded by the Australian station would be more relevant for predictions for India and would help reduce the variability. Farmers who were covered by the project were also present.

For further information:

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