MAUSAM, **59**, 4 (October 2008), 497-502

556.3.02 : 551.501.86

Delineation of potential groundwater zones in the Kagna river basin of Gulburga district, Karnataka, India using remote sensing and GIS techniques

M. RUDRAIAH, S. GOVINDAIAH and S. SRINIVASA VITTALA*

Department of Geology, Manasagangotri, University of Mysore, Mysore, India

**Central Groundwater Board, South-Western Region, Bangalore, India*

(*Received 8 April 2008, Modified 10 September 2008*)

e mail : sgovindaiah@rediffmail.com

सार – इस शोध पत्र में सुदूर संवेदी और जी. आई. एस. का उपयोग करते हुए बोरवेल के स्थानों के बारे में विवेचन करते हुए भूगर्भीय विन्यास आरेखित करने के साथ पृथ्वी के धरातल के आकार प्रकार के एककों के आधार पर कर्नाटक के गुलबर्गा जिले में कंगना नदी द्रोणी के भागों में संभावित भौमजल श्रोतों के बारे में बताया गया है। इस शोध पत्र में 1318 वर्ग किलोमीटर के क्षेत्र को लिया गया है तथा इसे वाडी, चितपुर, सेदम और कुरकुंटा उपद्रोणियों में विभाजित किया गया है जिनका क्षेत्रफल 184 से 537 वर्ग किलोमीटर के बीच का है। शैल विज्ञान के विषय के रूप में इस क्षेत्र में डेकन बसाल्ट के महीन आवरण के साथ एकीकृत, बलुआ पत्थर, स्लेटी पत्थर और चूनापत्थर से आच्छादित ग्रेनाइट के साथ आधार पार्श्वक अबरक भी आते हैं। जल भूपटलीय रचना समूचे क्षेत्र को खड़ी कटाव ढाल शैलपद, शैल पर द्विपाय गिरि क्षेत्र, उथले शैल पर, सामान्य शैल मैदान को कम से अधिक सूक्ष्म परीक्षण और जिनका सूक्ष्म परिक्षण नहीं किया गया है उन्हें पठार, घाटियों और उथली घाटी क्षेत्रों में वर्गीकृत किया गया है। अपवाह तंत्र और बाँध को बनाने वाले आरेख उत्तर उत्तर पश्चिम, उत्तर पश्चिम, पूर्व पश्चिम और उत्तर पूर्व दिशाओं में निधारित किए गए हैं। अधिकांश बोरवेल आरेखों के समीप हैं जिससे आरेख के भौमजल की गति के मार्ग दर्शक के रूप में कार्य करने का पता चलता है। ओरख और भूपटल रचना के विश्लेषण के आधार पर यह पता चला है कि संभावित भौमजल क्षेत्रों के लिए घाटी के क्षेत्र और सामान्य शैल मैदान काफी अच्छे से अच्छे हैं, उथले शैल मैदान और सूक्ष्म वर्गीकृत पठार अच्छे से सामान्य शैलपद सामान्य से खराब और शैलपद द्विभायगिरि क्षेत्र और खड़ी कटाव ढाल खराब से अत्याधिक खराब है।

ABSTRACT. The potential groundwater zones in parts of Kagna river basin of Gulburga district, Karnataka, have been delineated on the basis of geomorphic units alongwith geological setting, lineaments indicating bore well locations using remote sensing and GIS. The study area covers an area of 1318 sq km and it is divided into Wadi, Chitapur, Sedam and Kurkunta sub-basins which range in area from 184 to 537 sq km. Lithologically, the area consists of basement gneisses with granites overlain by conglomerate, sandstone, shale and limestone with a thin cover of Deccan basalts. Hydrogeomorphologically, the entire area is classified into escarpment slope, pediments, pediment inselberg complex, shallow pediplains, moderate pediplains, slightly to highly dissected and undissected plateaus, valleys and shallow valley fills. The lineaments representing drainages and dykes are oriented in NNW, NW, EW and NE directions. Most of boreholes are located nearer to the lineaments indicating that the lineaments are acting as pathways for the movement of groundwater. Based on lineament and hydrogeomorphic analysis, it is suggested that the valley fills and moderate pediplains are very good to good, shallow pediplains and dissected plateau are good to moderate, pediments are moderate to poor and the pediment inselburg complex and escarpment slope are the poor to very poor potential groundwater zones.

Key words – Remote sensing, GIS technique, Hydrogeomorphology, Lineaments.

1. Introduction

Groundwater is a very essential and valuable resource for the developmental activity. Hence, a proper evaluation and management of groundwater is required. Satellite remote sensing provides an opportunity for better observation and more systematic analysis of various hydrogeomorphic units, lineaments, following the synoptic multispectral repeatitive coverage of the terrain (Chakraborthy and Paul, 2004; Ravindra 1997; Nag, 2005 and Vittala *et al*., 2005). Since, there is no published literature with regard to evaluation of potential groundwater zones using remote sensing and GIS techniques, the present work has been undertaken in the Kagna river basin based on the hydrogeomorphic units and the lineament analysis including bore well locations.

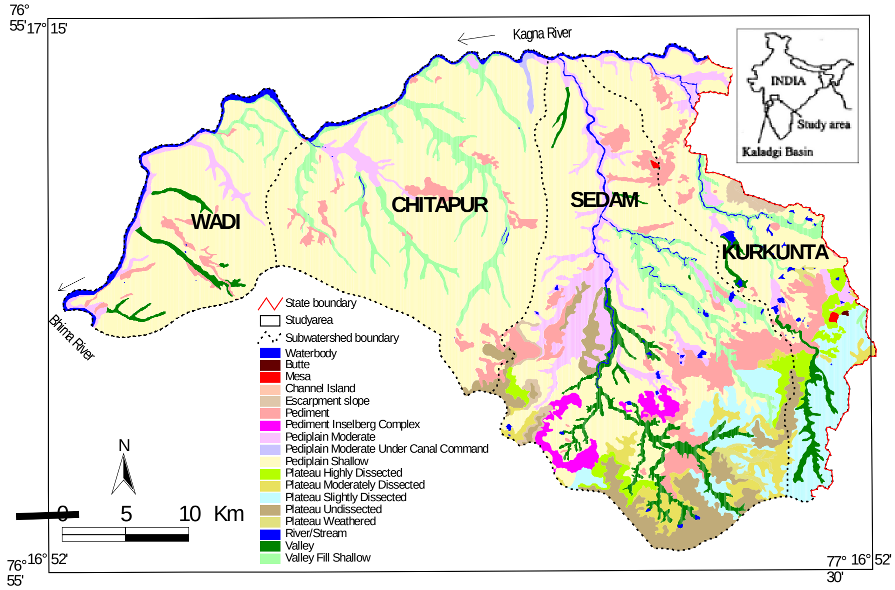

Fig. 1. Hydrogeomorphological map of the study area

1.1. *Study area*

The study area is located between Lat. 16° 52′ - 17° 15′ and Long. 76° 55′ - 77° 30′ and forms a part of Kagna river basin in Chitapur, Sedam and Yadgir taluks of Gulburga district of Karnataka. It forms the eastern part of sedimentary sequence belonging to the Bhima Group of rocks. The river Kagna is a tributary to the river Bhima. The river Kagna flows from east to west and confluences near Shahabad. The study area is sub-divided into Wadi, Chitapur, Sedam and Kurkunta sub-basins which range in area from 184 to 537 sq km.

1.2. *Geological setting*

A horizontal to nearly horizontal bedded Neoproterozoic sediments, predominently of limestone, occupying an area of 5,200 sq km in parts of Bijapur and Gulburga districts of Karnataka as well as Rangareddy districts of Andhra Pradesh was named as Bhima series by King (1872), after the river Bhima, which rises near Mahabaleshwar (Maharastra) in the western ghats and crosses in this basin in NW and SE direction. The Bhima series were later given a Group status and classified by different workers (Janardhan Rao *et al*., 1975 ; Mathur, 1977 and Kale *et al*., 1990) into five Formations namely Rabanapalli shale Formation, Kurkunta limestone Formation, Halkal shale Formation, Katamadevarahalli limestone Formation and Gogi shale Formation. The northern fringe of the Bhima basin is occupied by vast spread of Deccan traps of cretaceous to Eocene age. The granitoid embayments occur to the southern fringes of the basin.

The study area consists of basement migmatites and granodioritic tonolitic gneisses (270 sq km) of the Peninsular gneissic complex enclosing gray to pink granites (41sq km). These basement rocks are overlained unconformably by sedimentary sequences belonging to Bhima group represented by conglomerate, sandstone, shale (201 sq km), limestone (649 sq km) with thin cover of Deccan basalts (148 sq km) with laterite cover 9 sq km (Table 1).

The study area is characterised by undulatory topography with rugged hilly terrains consisting of gneisses and Deccan basalts in the southeastern portion of the area (Sedam and Kurkunta sub-basins). The general elevation of the land surface ranges from 380 m to 668 m from MSL and the highest peak is of elevation 668 m. The hilly terrain is covered with dense reserve forest whereas the plains are mainly of limestones covered with crop lands and villages. On the other sub-basins of the study area, a number of gullies originate from the highest peak of elevation confined to southeast and southern portion of the study area. These gullies joined together to form small streams and ultimately all the streams are moving towards north and join the main Kagna river which flows from east to west and finally confluneces near Shahabad to river Bhima in the western portion of the study area (Fig. 1)

TABLE 1

Area statistics of different lithological units

Lithological units	Area in sq km
Basalt	107
Basalt with intertrappeans with flows number 2	24
Fine grained flows No. 5 with intertrappeans marl	17
Green shale	66
Greenish yellow shale	1
Grey / pink granite	16
Laterite	9
Limestone	649
Migmatites and granodiorite - tonaltic gneiss	270
Pink and gray granite	25
Purple shale	77
Sandstone and conglomerate	57
Total area	1318

TABLE 2

Area statistics of different hydrogeomorphic units

Descriptions of the hydrogeomorphic units	Area in sq km
Butte	0.18
Channel Island	0.19
Escarpment slope	5.35
Mesa	0.80
Pediment	96.35
Pediment inselberg complex	14.30
Pediplain- moderate	91.46
Pediplain moderate under canal command	2.27
Pediplain-shallow	764.42
Plateau-highly dissected	25.76
Plateau- moderately dissected	32.47
Plateau-slightly dissected	65.22
Plateau-undissected	55.59
Plateau weathered	6.98
River/stream	20.53
Valley	51.76
Valley fill-shallow	84.37
Total	1318-00

2. Data used

Geocoded false colour composite of bands of 2, 3, 4 of IRS -1C and 1D LISS- III and PAN data of 2001 on 1:50,000 scale were used to classify the hydrogeomorphological units. The survey of India toposheets (56 C/16, 56 G/4, 56 G/8, 56 H/1 and 56 H/5) on 1:50,000 scale and field observation data were used to extract information on the hydrogeomorphic features and lineaments of the drainage basin (study area).

3. Methodology

The satellite imageries have been geo-referenced and merged data using image processing software ERDAS IMAGINE (v. 8.5) and thus merged data were used in the present investigation. The hydrogeomorphic and lineament maps including bore hole locations a were prepared using satellite imagery by GIS techniques.

4. Results and discussions

This paper emphasizes the use of satellite remote sensing data for preparation of thematic maps of hydrogeomorphology and lineaments with bore well locations to delineate the potential groundwater zones by GIS soft wares.

4.1. *Hydrogeomorphology*

The hydrogeomorphological map (Fig. 1) has been prepared based on specific tone, texture, size, shape and association characteristics of remotely sensed data. Hydrogeomorphologically, the study area is classified into escarpment slope, pediments, pediment inselberg complex, shallow pediplains, moderate pediplains, slightly to highly dissected and undissected plateaus, valley and shallow valley fills and the area covered by each geomorphic units for all the sub-basins are presented in Table 2.

Escarpment slope (5.35 sq km) is exhibited by the severe erosion of shale at the contacts of limestone in the western portion of Sedam sub-basin. Inselbergs occur as smooth and rounded isolated hills abruptly rising above the surrounding plains. They are made up of migmatites and granodiorite-tonalite gneisses. Pediments dotted with a number of inselbergs in these gneisses are called pediment inselberg complex. They are confined only to the southern portions of sedam sub-basin and they are exposed around the Itakal village and occupy an area of 14.30 sq km. Pediments are exposed in the form of undulating plains with moderate slope dotted with outcrops of granites often covered with thin layers of soil in all the four sub-basins (Wadi, Chitapur, Sedam and Kurkunta) of the study area (Fig. 1). They are occupying an area of 96.35 sq km. Shallow and moderately weathered pediplains are the prominent units occupying an area 855.88 sq km in the study area. These units are

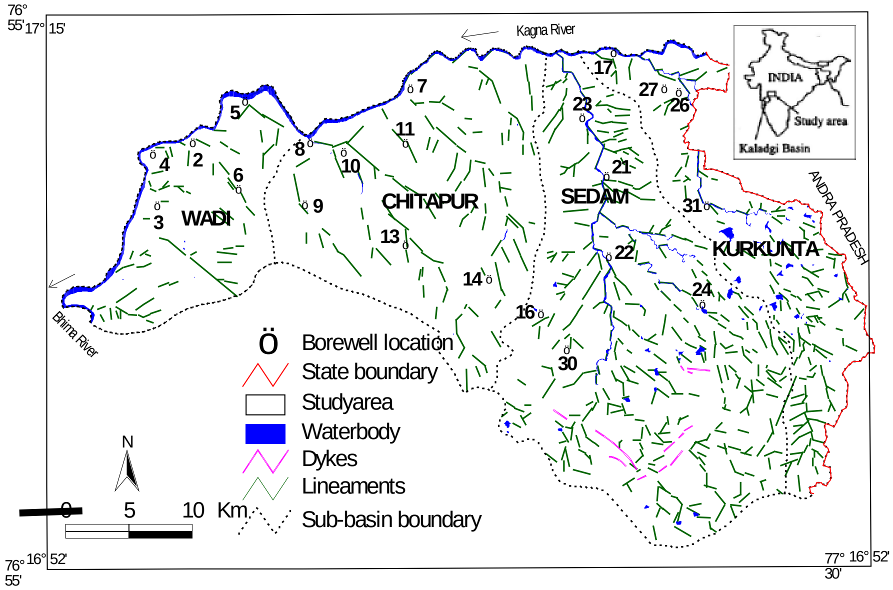

Fig. 2. Lineament map with location of bore wells of the study area

noticed in all the sub-basins of the study area, mainly in weathered zones of limestones followed by gneisses, shale and granites. In shallow weathered pediplains (764.42 sq km), the thickness of the weathered zones vary from 5 m to 15 m as revealed by the field checks in open wells, bore wells and exposures of these rocks. Very deep, well drained clayey soils are noticed on the undulating plains with moderate erosion in these units. The thickness of the weathered zones of moderate pediplains with moderate pediplains under canal command (93.73 sq km) varies from 15 m to 20 m as revealed by the borewell data. These units are confined to all the sub-basins and observed all along the banks of the valleys and also around the valleys. Maximum area is occupied by these units is in the Sedam sub-basin. Very shallow, well drained, loamy soils in valleys with severe erosion are observed in these units. Highly dissected plateau (25.76 sq km), moderately dissected plateau (32.47 sq km), Slightly dissected plateau (65.22 sq km), undisected plateau (55.59 sq km) and weathered plateau (6.98 sq km) are confined to the portions of basalts of Deccan plateau (traps) exposed in the southern and southeastern parts of Sedam and Kurkunta sub-basins (Fig. 1). In these units, moderately shallow, somewhat exclusively drained gravely loam soils with moderate erosion and associated with deep to very deep well drained clayey soils are noticed. Shallow valley fills are developed mainly in the limestone areas followed by gneisses, granites and shale in all the sub-basins with the maximum area occupied by the Chitapur sub-basin (Fig. 1). The total area covered by these units is 84.37 sq km followed by river/stream (20.53 sq km) and valleys (51.76 sq km) in all the sub-basins, butte (0.18 sq km), Chanel island (0.19 sq km) and mesa (0.80 sq km)

4.2. *Lineaments*

Lineaments are the most important structural features from the point of view of occurrence and movement of groundwater. They are the linear or curvilinear features and play a vital role in geomorphic and structural analysis. Lineaments in the form of fractures, joints, faults provide important clue on surface features and are responsible for infiltration of surface run off into the sub-surface and also for movement and storage of groundwater (Subba Rao *et al*., 2001). A detailed land form study made with LISS III image and topographic maps suggested that Kagna river drainage basin is characterized by highly permeable sub-soil which is evident by broad valley zones and low relief. The morphometric analysis of the drainage pattern of both linear, areal and relief characteristics indicates the dendritic to sub-dendritic patterns with stream orders IV to VII with coarse to moderate texture (Rudraiah *et al*., 2008).

The lineaments of the study area, were picked up by visual interpretation of IRS 1C and 1B satellite imageries, on the basis of tone, texture and drainage linearities, curvilinearities and rectilinearities. The lineament map representing mainly drainage lineaments and dykes of individual sub-basins has been prepared and presented (Fig. 2). The lineament analysis indicates that the majority of lineaments are oriented in NNW, NW, EW, NNE and NE directions. The length of the lineaments generally

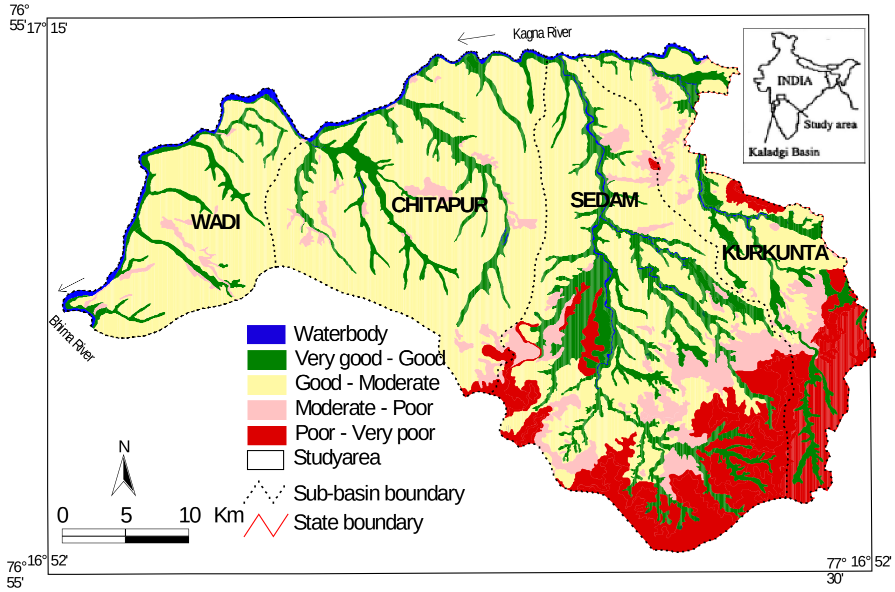

Fig. 3. Groundwater potential zone map of the study area

range from 0.35 to 5.2 km. It is noted from the remote sensing satellite imagery that the direction of the streams are NNW, NW, EW, NNE and NE direction and coincide with the direction of the lineaments. The lineaments representing dykes are oriented in NW, NE and almost EW directions. The lineaments identified in the pediplains, pediment inselberg complex and pediments and valley fill zones and plateau regions of the study area indicate that they are controlling the river channels and nallahs. It is also noticed from the lineament map that the areas of maximum concentration and intersection of lineaments indicate that these areas are the most probably potential areas of groundwater accumulation. High concentration of drainage lineaments is noticed in the southern portions of the Sedam and Kurkunta sub-basins where the gneisses, shale and Deccan basalts are the prominent rock types, whereas low to moderate concentration of lineaments is noticed in the limestones, shales and younger granites confined to northern portion of the Sedam sub-basin and also Wadi and Chitapur sub-basins.

In the lineament map, the location of about 31 existing bore wells in all the four sub-basins of the study area is presented (Fig. 2). It is noticed that majority of the bore wells and the villages are situated nearer to the drainage lineaments. Hence, it can be suggested that these lineaments are acting as pathways for the movement and storage of groundwater in the study area. Dykes are confined only to migmatites and gneisses of the study area mainly in the Sedam sub-basin. These dykes are represented by dolerite and they are acting as barriers for the movement of groundwater from south to north. This is indicated by the absence of drainage lineaments around the dolerite dykes.

TABLE 3

Area statistics of different groundwater potential zones

Groundwater potential zones	Area in sq km
Very good – good groundwater potential zones	235
Good – moderate groundwater potential zones	765
Moderate – poor groundwater potential zones	111
Poor – very poor groundwater potential zones	186
Water body	21
Total	1318

4.3. *Potential groundwater zones*

The potential groundwater zones in the study area are delineated based on the geology, soils, hydrogeomorphic units, density of lineaments and bore well locations. The occurrence and movement of groundwater is restricted to weathered zones preferably through the joints and interconnected fractures developed in limestones, gneisses and the thick soil horizons and highly weathered portions of Deccan basalts.

Four potential groundwater zones are identified according to their water bearing capacity as very good to good, good to moderate, moderate to poor and poor to very poor. Potential groundwater zone map has been prepared and presented (Fig. 3). The area covered by these zones is presented in Table 3.

The valley fill zones and moderately weathered pediplains with high lineament density and presence of a number of bore wells are considered to be very good to good potential groundwater zones covering an area of 235 sq km in all the sub-basins of the study area.

The shallow weathered pediplains consisting of mainly limestones and dissected and weathered plateau regions of Deccan basalts are good to moderate potential groundwater zones because of weathered mantle of these rocks. The presences of most of the villages on these rocks are due to its fairly good groundwater and soil conditions. These zones cover an area of 765 sq km in all the sub-basins of the study area.

The pediments contribute for a limited to moderate recharge with low lineament density and the presence of only a few number of bore wells in these zones indicating that they are moderate to poor potential groundwater zones covering an area of 111 sq km in all the sub-basins of the study area.

The pediment inselberg complex and escarpment slopes are confined to only Sedam and Kurkunta sub-basins in the southeastern portion of the study area are considered to be poor to very poor potential groundwater zones. In these zones, the lineament density is very low and there is no bore well data available for these zones.

5. Conclusions

The results of the present investigation indicates that remote sensing and GIS techniques have been proved to be very useful tools for delineating potential groundwater zones based on the geology, soils, geomorphic units, lineaments and bore well data. The lineament analysis indicate that the majority of the lineaments are oriented in NNW, NW, EW, NNE and NE directions which coincides with the directions of the streams. Based on the presence of maximum number of existing bore wells near the lineaments indicate that the lineaments are considered to be pathways for the accumulation and movement of groundwater. Hydrogeomorphologically, the study area is divided into escarpment slope, pediments, pediment inselberg complex, shallow pediplains, moderate pediplains, slightly to highly dissected and undissected plateaus, valleys and valley fills. Based on the relationship of these geomorphic units with the rock types, lineament density and borewell locations, it is concluded that valley fills and moderate pediplains are very good to good, shallow pediplains and dissected plateaus are good to moderate, pediments are moderate to poor and the pediment inselberg complex and escarpment slopes are poor to very poor potential groundwater zones.

Acknowledgement

One of the authors (M. Radraiah) is thankful to Prof. H. T. Basavarajappa, Chairman, DOS in Geology, Manasagangotri, University of Mysore, Mysore, for providing laboratory facilities to complete this work.

References

Chakraborty, S. and Paul, P. K., 2004, "Identification of potential groundwater zones in the Baghmundi block of Purulia district, West Bengal using remote sensing and GIS", *Jour. Geol. Soc. India*, **64**, 69-73.

Janardhana Rao, L. H., Rao, Srinivasa and Ramakrishna, T. L., 1975, "Reclassification of the rocks of Bhima basin, Gulburga district, Mysore State", GSI, *Misc., Publi*., **23**, 2, 177-184.

Kale, V. S., Madhukar, A.V., Phansalkar, V. G. and Peshwa, V. V., 1990, "Stratigraphy of the Bhima Group : *Journal of the Palaeontological Society of India*", **35**, 91-103.

King, W., 1872, "The Kudapah and Karnaul Formation in the Madras Presidency", *Mem. Geol. Surv. India*, **8**, 1-346.

Mathur, S. M., 1977, "Some aspects of stratigraphy and limestone resources of the Bhima Basin", *The Ind. Mineral*., **18**, 59-64.

Nag, S. K., 2005, "Application of lineament density and hydrogeomorphology to delineate groundwater potential zones of Baghmundi Block, Purulia district, West Bengal", *J. Indian Soc. Remote Sensing*, **33**, 4, 521-529.

Ravindra, K. V., 1997, "Drainage morphometry analysis and its correlation with geology, geomorphology and groundwater prospects in Zuvari basin, south Goa, using remote sensing and GIS", Proc. Nat. symp – Remote sensing for natural resource with special emphasis on water management held at Pune during 4-6, December 1996, 270-296.

Rudraiah, M., Govindaiah, S. and Srinivasa Vittala, S., 2008, "Morphometry using remote sensing and GIS techniques in sub-basins of Kagna river basin, Gulburga District, Karnataka, India", (in press). *J. Indian Soc. Remote Sensing*.

Subba Rao, N., Chakradhara, G. K. J. and Srinivas, V., 2001, "Identification of groundwater potential zones using remote sensing techniques in and around Guntur town, Andhra Pradesh, India", *J. Indian Soc. Remote Sensing*, **29**, 1&2, 69-78.

Vittala, S. S., Govindaiah, S. and Honnegowda, H., 2005, "Evaluation of groundwater potential zones in the sub-watersheds of north Pennar river basin around Pavagada, Karnataka, India using Remote sensing and GIS techniques", *J. Indian. Soc. Remote Sensing*, **33**, 4, 483-493.