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A Study on the Impact of Landuse Pattern in the Groundwater Quality in and Around Madurai Region, South India-Using GIS Techniques

[1]S. Chidambaram, [1]A. John Peter, [3]M.V. Prasanna, [1]U. Karmegam,
[1]K. Balaji, [1]R. Ramesh, [1]P. Paramaguru and [2]S. Pethaperuaml
[1]Department of Earth Sciences, Annamalai University, 608002 Annamalai Nagar, India
[2]Department of Agriculture, State Groundwater Unit and Soil Conservation, 605009 Pondicherry, India
[3]Department of Applied Geology, School of Engineering and Science,
Curtin University of Technology, Sarawak, Malaysia

Abstract: The study was aimed to identify and delineate the groundwater potable zone in and around Madurai region. The study area is composed of Charnockites and Khondalites of Archaean age. The information of lithology, geomorphology and land use/land cover was generated using the Resourcesat (IRS P6 LISS IV data) and Survey of India (SoI) toposheets of scale 1:50,000 and integrated them with GIS to identify the groundwater potable zones of the study area. On the basis of hydrogeomorphology, groundwater potential zones was identified and delineated. From the overlay analyses of landuse and EC, it is inferred that poor category groundwater is found in the scrub forest, current fallow, canal and scrub with land areas.

Key words: GIS technique, groundwater, zones, river system, EC, India

INTRODUCTION

Groundwater is a dynamic and replenishable natural resource but in hard rock terrain availability of groundwater is of limited extent and its occurrence is essentially confined to fractured and weathered zones. The occurrence, origin, movement and chemical constituents of groundwater are dependent on the geologic frame work i.e., lithology, thickness, structures and permeability of the rocks through which it moves. Exploration and utilization of groundwater especially in hard rock terrains, requires thorough understanding of geology, geomorphology and lineaments of the area which directly or indirectly control the terrain characteristics.

Krishnamurthy and Srinivas (1996), Ravindran and Jeyaram (1997) and Jagadeeswara *et al.* (2004) used the satellite remote sensing data to define the spatial distribution of different groundwater prospect classes on the basis of geomorphology and other associated parameters.

Murthy *et al.* (2003) and Khan *et al.* (2006) reported that temporal data from the remote sensing enables identification of groundwater aquifers and assessment of their change whereas GIS enables user specific management and integration of multi-thematic data. The present study focus on the identification of groundwater potable zones in and around Madurai region using remote sensing and GIS.

Study area: The study area lies in the Western Ghat region of Tamilnadu between North latitudes 78°00'-78°15' and East Longitudes 9°15'-10°00' (Fig. 1). It falls in survey of India map 58 K/1. The Northern part of the study area bounded by Trichy, Dindugal, Sivagangai districts in the East; Theni district in West; Virdunagar district in South. The total geographical extent of the study area is 780.49 Km^2.The annual average rainfall in the district is 855.5 mm. The average maximum temperature for the district as a whole is about 34.1°C and average minimum temperature is 23.6°C.

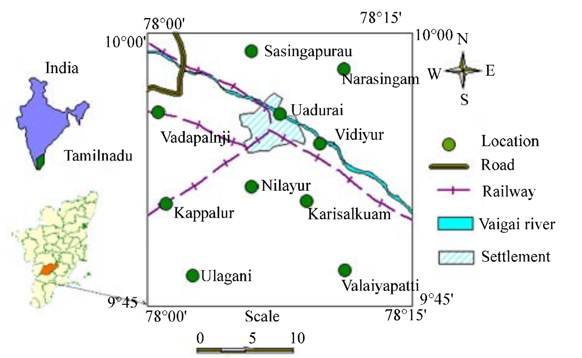

Fig. 1: Location map of the study area

Corresponding Author: S. Chidambaram, Department of Earth Sciences, Annamalai University, 608002 Annamalai Nagar, India

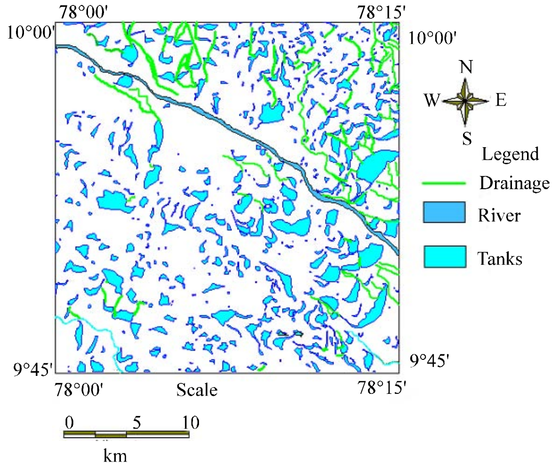

Fig. 2: Drainage map of the study area

Physiography: A north-south trending range of hill forming part of Western Ghat marks the western boundary with Kerala, Palani hills form the northern spur and high wavy mountain, the Varushnad and Andiapatti hills form the southern spur of this range. Palani hills range in height from 3000-8000 above MSL. In the eastern parts of the district, the Sirumalai hill range located it has a small scale plateau with an elevation of 401-1379 meters above MSL.

In the southeastern part of the area, Nagamalai Pudukkottai structural hill ranges are needed in the SE part. The adjoining of the district is characterized by undulating plain covered mostly by red soil (85%).

Drainage: The main river system that feeds the Madurai district is Vaigai River system. Vaigai River originates from the Western Ghats on the Cumbum valley. The Govundan Nadi, Manjal Ar. is another tributary. Vaigai is the only river which has amajor catchment area of which falling in Madurai district. Of the total length of 249 km, nearly 210 km runs through the composite Madurai district comprising the Theni district. The area of Vaigai basin is 3913 Km^2 (Fig. 2).

Geology: The main rock type's encountered fall into two groups: Charnockites and Khondalites of Arechaean age. The charnockite group of rocks consists of the acid charnockite and related Migamatites with bands of basic Granulites and Magnetite-Quartzite.

They form the country rocks in Palani, Varushanad, Andipatti and the Sirumalai hills. The Khondalite group of rocks consists of crystalline Limestone, Calc-gneiss, Calc-granulite, Garnet Sillimanite gneiss, Hornblende and Biotite-gneiss and related migmatites with bands of Quartzite.

MATERIALS AND METHODS

In the present study, Resourcesat (IRS P6 LISS IV data) in the form of FCC generated from band 2, 3, 4 on 1:50,000 scale were used. The base maps were prepared from Survey of India Toposheets (Scale1:50,000). For spatial distribution and overlay analyses MapInfo Professional 7.8 was used. About 41 groundwater samples were collected to cover entire lithology of the study area. EC was determined in the field using electrode (Eutech).

RESULTS AND DISCUSSION

Geomrphology: Geomorphologic maps help to identify various geomorphic units and ground water occurrence in each unit. Selected field checks were carried out in the field to verify different geomorphic units (Table 1). Geomorphology and associated features as identified through the visual interpretation of satellite imagery represented are Shallow Pediment (SP), Pediment (PD), Flood Plain (FP), Deep Pediment (DP) and Structural Hill (SH) (Fig. 3).

Studying the importance of geomorphology for groundwater in Madurai region through remote sensing, flood plains are interpreted by its typical reddish tone found along the banks of the river courses. The flood plain area comprises mainly of sands and silts with minor inter clarified of clays and they act as good aquifers.

The groundwater potential of flood plain is very high. The notable feature of this study is the demarcation of flood plain in the Vaigai river system which resulted in the excellent groundwater potential.

Landuse/land cover: For the identification and interpretation of land use pattern of the area, image interpretation through remote sensing data (IRS P6 LISS IV) were adopted and the various land use classes delineated includes residential area, industrial area, commercial area, recreational area, vacant land, villages, crop lands, plantation, scrub forest, salt affected land land with scrub, stony waste, mining process, river-water channel area, river-sandy area, river-island, river-river bed vegetation, canal and tank (Fig. 4). Out of the total area, 22% is falling under crop land area (Table 2). Impact of urbanization has taken its own

Table 1: Geomorphologic units and their groundwater prospect in the area

Geomorphic units	Groundwater prospects
Shallow pediment	Poor
Pediment	Very poor
Flood plain	Very good
Deep pediment	Poor
Structural hill	Poor

Table 2: Identified features in land use map (km^{-2})

Land use/land cover	Area in km^2
Town/cities (urban) residential	71.02
Town/cities (urban) industrial	3.12
Town/cities (urban) commercial	1.28
Town/cities (urban) recreationl	1.49
Town/cities (urban) public and semi-public	9.23
Town/cities (urban) open space/vacant land	0.09
Town/cities (urban) others	1.27
Villages (rural)	19.49
Crop land-rabi	168.20
Crop land-kharif+rabi (double)	119.70
Fallow-current fallow	49.75
Plantations	79.10
Plantations-rubber	7.56
Deciduous (moist/dry)-scrub forest	6.94
Salt affected land	20.90
Land with scrub	96.62
Barren rocky/stony waste/she	0.91
Mining process	1.86
River-water channel area	8.58
River-sandy area	0.20
River-island	0.02
River-river bed vegetation	0.49
Canal	1.37
Tanks-water spread area	0.15
Tanks-sandy area	0.04
Tanks-tank bed cultivation	0.16
Tanks-tank bed vegetation	108.20
Tank-tank bed settlement	2.76
Total	780.49

credit in causing damage to natural ecosystem. Major ion and trace element geochemistry of acidic septic tank system plume was studied by Robertson and Blows (1995) and Ramaraju *et al.* (1999) along with a problem in shallow water table aquifers.

Impact of landfills on groundwater resources was also attempted by Howard *et al.* (1996). Similar studies were also carried out by Cox *et al.* (1996), Grischek *et al.* (1996) and Lerner and Barrett (1996).

GIS analysis: Spatial distribution of Electrical Conductivity (EC) for groundwater samples was done using MapInfo Professional GIS software (Fig. 5). In the study area, EC varies between 191-11900 μs cm^{-1} with an average of 2391 μs cm^{-1}. Groundwater with EC below 1500 μs cm^{-1} is portable (WHO, 1993).

Higher EC was noted in the SE direction along down stream side of Vaigai River. Considering the spatial distribution of EC, overlay analyses have been attempted for groundwater using GIS by super imposing the

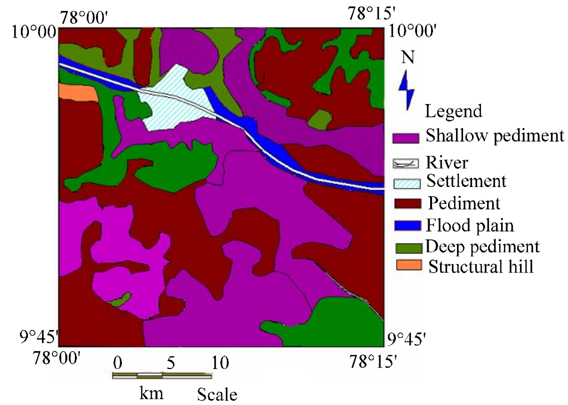

Fig. 3: Geomorphology map of the study area

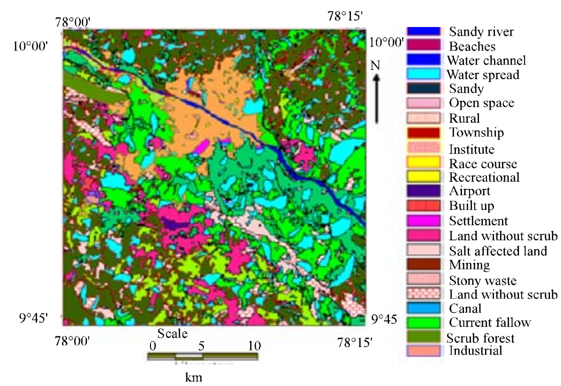

Fig. 4: Land use map of the study area

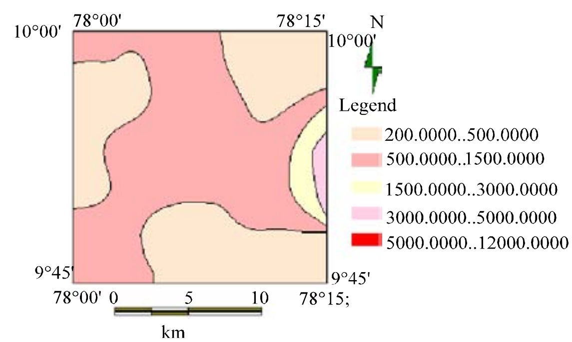

Fig. 5: Spatial distribution of EC in μm cm^{-1}

land use and EC layers. This overlay analysis reveals that (Fig. 6), poor category groundwater is found in the scrub forest, current fallow, canal and scrub with land areas. The impacts of mining and agricultural and other anthropogenic activities have also proved to affect the quality of groundwater (Joshi *et al.*, 1982; Kakar *et al.*, 1989; Krishnaswamy *et al.*, 1993; Lakshmanan *et al.*, 1986; Miller *et al.*, 1997; Krishnappa and Shinde, 1980; Anandhan *et al.*, 2000).

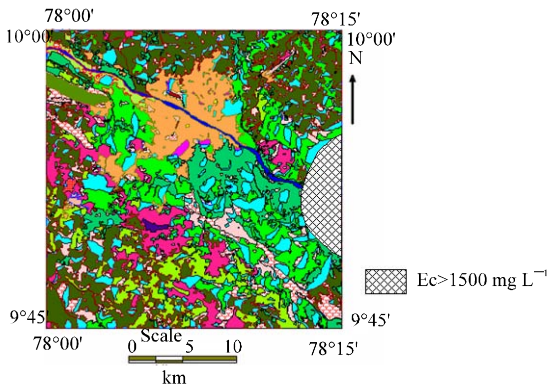

Fig. 6: Overlap map of land use and EC

CONCLUSION

The study has focused on the utility of remote sensing and GIS in the identification of groundwater potable zones in the Madurai district. The hydrogeomorphological units developed under various terrain conditions were mapped and identified the good potable water along the flood plains.

Over lay analyses for EC and land use map indicates poor category groundwater is found in the scrub forest, current fallow, canal and scrub with land areas. Thus, the above study has demonstrated the capabilities of a remote sensing data and GIS technique for demarcation of groundwater potable zones in the study area. The current multiparametric approach using GIS and remote sensing is holistic in nature and will minimize the time and cost especially for identifying groundwater-potable zones.

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