©Kamla-Raj 2003 J. Hum. Ecol., 14(5): 337-342 (2003)
PRINT: ISSN 0970-9274 ONLINE: 2456-6608 DOI: 10.31901/24566608.2003/14.05.04

Groundwater Management Using Remote Sensing Data in Urban Environment: A Case Study of South Delhi Region (India)

Surendra Kumar Yadav

INTRODUCTION

Principle source of groundwater in Delhi is high intensity rainfall and considerable seepage from canals, riverbed and lateral flow from adjacent areas. Semi arid region of part of South Delhi covered by quartzite ridge in places often experience acute shortage of drinking water. Groundwater conditions are mainly controlled by geology, lithology, structure, vegetation cover, landuse, relief and degree of weathering. Lineament analysis, vegetation anomaly and hydromorphogeological studies in and around New Campus of Jawaharlal Nehru University, infers groundwater potential areas, surface runoff, groundwater recharge and the areas of groundwater discharge.

An attempt has been made to study the changed landuse pattern of the area, which has been demonstrated to have a direct bearing on the infiltration capacity which depends on soil properties. Ground water occurrence at any place on earth is not a matter of chance but a consequence of the interaction of climatic, geologic, hydrologic, physiographic, pedologic and ecological factors. Search for groundwater, particularly in areas with consolidated and semi-consolidated rock formations, considered more difficult from the point of view of exploration, is considerably aided by the use of hydromorphogeological maps prepared using satellite imagery. These maps depict spatial information on various hydromorphogeological units including structural lineaments having different groundwater prospects.

STUDY AREA

The study area lies between latitudes 28° 29' 00'' to 28° 35' 00'' E and longitudes 77° 3' 00'' to 77° 16' 00'' N. The study area falls in the survey of India topographical sheet No. 53 H/ 2. Study area has dominantly quartzite and pegmatite as dissected ridges. Physiographically, this is a part of Aravalli mountain system and is known as Southern ridge or Delhi ridge. The general slop of the area is towards North to Northeast. The mean annual rainfall is 750 mm, with a minimum of 320 mm and maximum of 1250 mm. The topography of the area is highly uneven with developed drainage system.

DATA USED AND METHODOLOGY

The present study was carried out by visual interpretation and digital image analysis of Remote sensing or satellite (SPOT and IRS 1-A) data. The data used in the study were IRS- 1A LISS II, Geocoded False Colour Composite (FCC) on 1: 50,000 scale [Path 29, Row 47, Date: 07.03.1992]; SPOT Multispectral False Colour composite on 1: 25,000 scale [Path 207, Row 293, Date: 09.11.1987]; SPOT Multispectral computer compatible tape (CCT) [Path 207, Row 293, Date: 09.11.1987] and Survey of India topographical sheet No. 53 H/ 2/ SE on 1: 245,000 scale.

The study has been carried out using the methodology of visual interpretation of SPOT FCC and IRS- 1A to study the geology, hydrmophogeology structural features and Landuse of the area; digital enhancement of SPOT CCT for delineating geomorphic and structural elements in the study area; preparation of hydromorphogeological and landuse map from satellite imageries for study of groundwater potentiality and change in recharge capacity by changed landuse patterns; and finally interpretation of most suitable sites for check dam site to conserve water.

SATELLITE REMOTE SENSING STUDIES

Hydromorphogeological investigations of the study area for groundwater targeting and landuse studies are based on the interpretation of SPOT and IRS- 1A data. Following features were delineated which were further confirmed by ground truth in the field:

Lineament: These are linear features marked by change in tone, texture and spectral reflectance. Quartzites are forming a set of lineaments (Jha and Roy, 1985). General trend of quartzites are characterized by several sets of well developed fractures and joints which are as following:

(a) NNE-SSW (Parallel to bedding) with steep easterly dips.
(b) EW to ENE-WSW, vertical.
(c) NW-SE, vertical, perpendicular to strike.

Two lineaments of EW trend are prominent in Northern part of the JNU New Campus, while less conspicuous lineaments are along NW-SE direction. These lineaments have a control over the drainage in the area. Some of the lineaments are found filled up with clay (Kaolin) derived from weathering of pegmatites, which are found occasionally alongwith vein quartz employed along fractures and joints in quartzite (Dey et al., 1984).

Hydromorphogeology: Hydromorphogeological studies are based on rock types, their structure and erosion characteristics which ultimately forms pediment deposits. The compact grey quartzites are highly resistant to weathering and they stand out as jointed, blocky or subrounded boulders as a result of intersecting joints. Arkosic and ferruginous quartzites are easily weathered which results in sandy or gritty, red soil (Sen, 1972). A brief resume of hydromorphogeology of JNU New Campus and surrounding area is given in Table 1.

(i) *Residual/ Structural Hills:* These are parts of Aravali - Delhi - Hardwar ridge, which is exposed to JNU New Campus and forming N-S to NE- SW trending structural ridges, tors, inselbergs and composed of folded and jointed quartzites. Some of the open joints allow limited ground water infiltration while some joints are filled with secondary argillaceous material which restricts the groundwater infiltration. Since it is a part of surface runoff zone and therefore has very poor groundwater prospects. In satellite imagery these are easily picked up by barren nature with scanty vegetation along joints and slopes.

(ii) *Pediment:* This part of Hydromorphogeological units constitutes of undulating, eroded and along the fringes and slopes of ridges and tors. The soil characteristics determine the drainage pattern. The groundwater depth is considerably deeper in clayey and fine silty soils than in gritty and gravelly soils. Drainage density is also more in clayey/ fine silty soils which often leads to gullies formation. Weathering is more severe in coarse gritty or arkosic quartzite. The northern quadrant of JNU New Campus is suitable pediment complex for groundwater exploration. Interconnected lineaments are showing vegetation anomalies, which are inferred as higher infrared reflectance in SPOT 321 band combination.

(iii) *Buried Pediment:* North eastern part of JNU New Campus is comparatively low lying area and forms buried pediments. It has a shallow to moderately thick soil cover, which is mostly silty and clayey and in places gritty and gra-velly. The surface slopes gently towards north east and merges with the

Table 1: Hydromorphogeology of JNU New Campus, New Delhi, India

S. No.	*Geomorphic unit*	*Landform*	*Geology*	*Ground water prospectus*
1	Residual/ Structural Hill	Rocky ridges, tors and mounds	Massive, compact jointed quartzite	Very poor
2	Pediment	Undulating eroded and dissected, shallow buried pediment with rock exposures. Thickly vegetation with scrubs.	Weathered coarse gritty or arkosic quartzite with cover of clayey and silty soil along stream courses.	Generally poor but moderate to good along fractured & sheared zones.
3	Buried Pediment	Plain to gently sloping ground with occasional rock outcrops.	Silty, clayey and at places gravelly soil derived from weathering of arkosic and gritty quartzite.	Moderate to good along fractures and drainages.

deeply buried pediment, further north east of the campus and with the yamuna alluvial plain further east. This unit forms a moderate to good groundwater potential region especially along fractures and drainages.

Based on the lineament studies and drainage pattern analysis nine suitable points are recommended for groundwater exploration. For surface water management interception of surface runoff by check dams across drainage at appropriate locations is one method of surface water management. In the study area a series of check bunds with pipe outlets are suggested for rainwater harvesting. Locations for such structures have been selected where the valley section is narrow and maximum spreading up of stream, with least bearing on the height of the structure is possible. Some check dams can be recommended to harvest the water (Manchanda et al., 1993).

Table 2: Depth to water levels in (m.) (b.g.l.) in and around study area

Sr. No.	*Location*	*Year*	*Jan.*	*Apr.*	*May*	*June*	*Aug.*	*Nov.*
1.	RK Puram, IV	1978	-	-	-	-	04.79	04.58
		1979	05.13	05.30	-	06.26	06.52	07.01
		1980	06.76	06.87	-	07.96	06.55	06.86
		1981	06.80	07.54	-	08.18	06.33	03.92
		1982	06.75	08.04	-	08.00	08.60	08.70
		1983	08.69	08.82	-	09.05	08.10	07.98
		1984	08.55	09.04	-	09.46	09.25	08.41
		1985	08.94	-	-	-	09.24	09.17
		1986	09.44	-	10.53	-	10.96	10.59
		1987	Dry					
2.	RK Puram, III	1978	-	-	-	-	04.06	04.05
		1979	04.33	04.45	-	05.59	03.96	04.14
		1980	04.42	-	-	04.52	03.77	03.78
		1981	04.40	-	-	-	03.56	-
		1982	04.12	04.19	-	04.23	03.30	-
		1983	-	03.70	-	04.04	03.95	-
3.	Masudpur	1983	-	-	-	-	05.65	05.53
		1984	05.40	06.45	-	07.31	05.65	05.53
		1985	06.94	-	07.00	-	06.70	07.02
		1986	07.25	-	07.61	-	07.77	07.81
		1987	08.01	-	08.16	-	08.45	08.43
		1988	08.57	-	09.10	-	07.90	07.08
		1989	07.05	-	07.93	-	08.67	08.98
		1990	-	-	-	-	-	06.86
		1991	02.58	-	07.69	-	08.00	08.04
4.	Munirka	1978	17.26	17.56	-	18.67	18.23	15.90
		1979	15.67	16.13	-	17.21	17.08	18.21
		1980	18.40	11.46	-	20.86	20.10	19.99
		1981	20.11	20.85	-	21.75	-	17.20
		1982	20.15	20.52	-	21.07	21.06	21.80
		1983	21.39	21.75	-	21.99	20.82	19.33
		1984	19.16	19.52	-	20.11	20.30	19.60
		1985	19.50	-	24.30	-	-	26.86
		1986	25.17	-	24.37	-	25.05	26.09
		1987	23.61	-	22.80	-	23.20	23.21
		1988	22.46	-	24.05	-	21.00	21.18
		1989	21.04	-	21.41	-	21.94	22.22
		1990	-	-	-	-	22.28	20.39
		1991	20.07	-	20.46	-	20.88	19.72
		1992	19.79	-	20.44	-	20.76	-

Source: C.G.W.B., Ministry of Water Resources, Govt. of India

Application of Remote Sensing in Recharge Area Studies

SPOT (FCC) of 0.50 m to 0.89 m data, IRS-1A LISS II of 0.45 to 0.86 data have been used for delineation of the recharge area for study area. The JNU New Campus of Jawaharlal Nehru University (New Delhi) area is drained by three drainage systems, forming structurally controlled subdendritic to subparallel pattern. The main streams are controlled by formation of strike (NS to NE- SW), while the minor drainage by fractures and joints. All the drainages are dry except in rainy season. General slope of the study area is NNE, towards the river Yamuna. For the JNU New Campus the recharge area lies in SSW direction near Masudpur village.

The SPOT data shows the change in landuse pattern, which has adverse impact on the infiltration on rainwater which forms the groundwater. Very high albedo of semi-circular outline has been found by using multispectral SPOT data in SSW of JNU New Campus, New Delhi. The albedo (white patches) are areas of disused and underu-

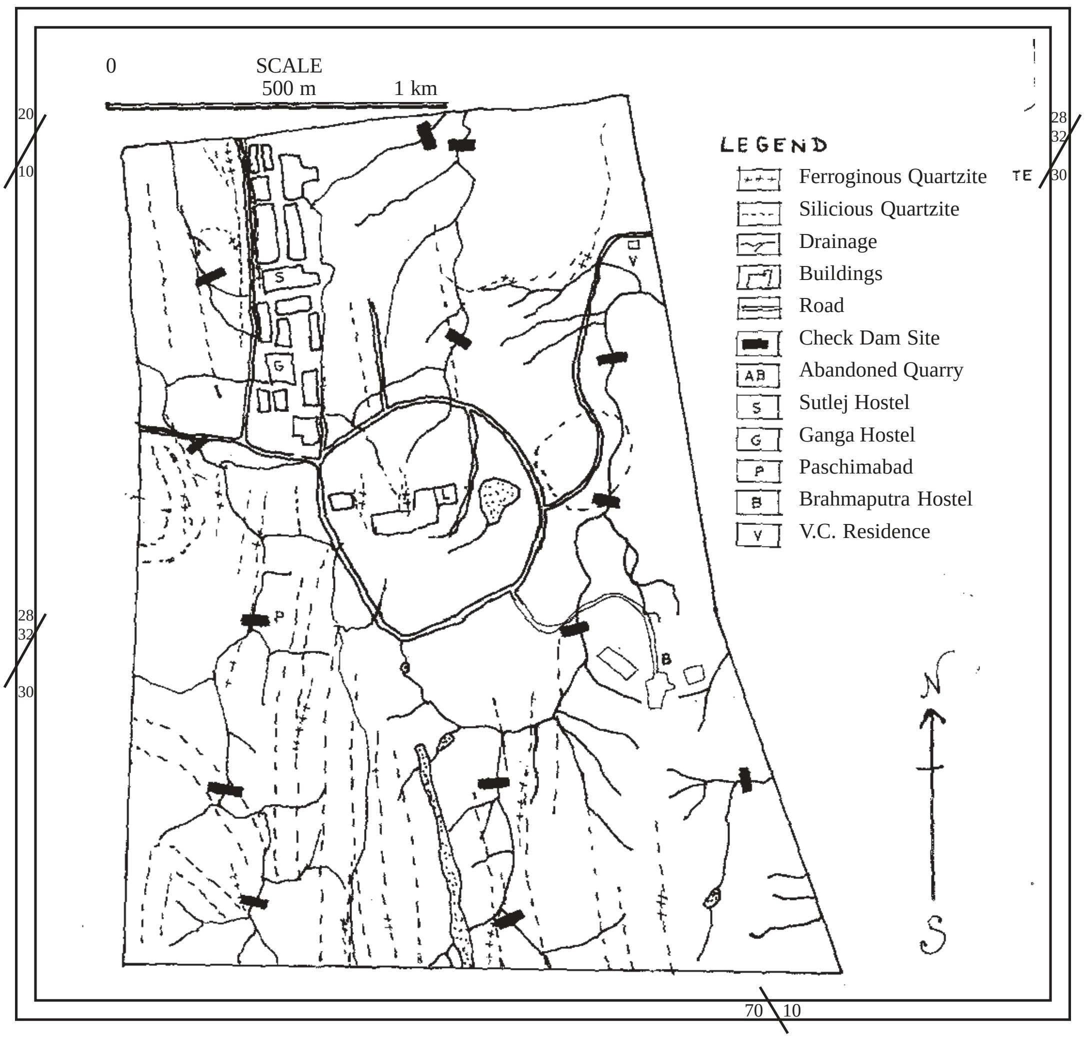

Fig. 1. Geology of JNU Campus New Delhi (Based on Remote Sensing data)

sed brick kilns which have been in operation since approximately last 50 years. The brick kiln complex covers approximately an area of 6.885 square Km (Yadav, 1994). In certain localized stretches the clay content is high. Continuous cover of vegeta-tion and high moisture contents in the soils of these areas not only minimize the removal of fine elastics by wind action, but also facilitates podsolisation, thereby increasing the clay content in the soil. These areas form potential brick kiln areas (Dey, 1985).

The land area covered by brick kilns have been repeatedly heated and cooled since last 50 years which has caused the change in soil texture such that it does not permits the rain water to infiltrate to the groundwater. Besides, hundreds of small groundwater structures like borewells and dugwells have been structured for the supply of water to the brick kiln area. This further extracts the available groundwater formed by recharge from a distant area. The resultant effect is lowering down of depth of water level in the study area (Table 2). It is evident by the depth to water level data of R. K. Puram (Sector IV) where water level has gone down from 4.79 m to 10.59 m below ground level from 1978 to 1987. Likewise in Munirka area water level has gone down from 15.90 m to 20.76 m. Further SSW of these areas Masudpur shows lowering down of water level from 5.53 m to 8.93 m below ground level.

The changed landuse pattern is one of the reasons of lowering down of water level, which is indirectly inferred by SPOT data. The brick kiln areas are devoid of vegetation, which are inferred by using band combination 321. Visible wave-length region provides better information than the infrared wavelength region for determining the organic matter content (Krishnan et al., 1980). Clayey soil with iron concretions and silt influence the intensity of energy reflected by soils in the 0.5 m to 2.6 m range. Significant correlations were found among the spectral radiance data and soil variable studies (Coleman et al., 1993). Masudpur village and its surrounding areas shows a large number of brick kilns (42 in number) which are partially responsible for lowering down of groundwater level in JNU New Campus. Only few selected species like *Ichnocarpus, Saccharum, Datura, Tephrosia, Boerhavia, Eragrostiella, Pycreus, Calotropis, Euphorbia hirta, Triantche-ma portulacastrum, Croton sparsiflorum, Tribulus terrestris* and *Cynodon dactylon* etc. can grow on these disused brick kiln areas.

CONCLUSION

Due to urbanization and industrialization, changed landuse pattern inferred by albedo as brick kiln areas have low infiltration capacity. Grooundwater potentiality depends on hydro-morphogeology of the study area (Table 1). Burried pediment plains and vegetation anomaly in lineament intersection are potential aquifers. Buried pediment areas along fractures and drainage have good water prospects while resi-dual/ structural hills are very poor in water bearing capacity. Six priority areas are selected for exploratory drilling purpose for tube wells. Since the water level of the whole study area has gone down (Table 2). Based on Remote sensing data interpretation (using environmental and geological parameters), fourteen check dams/ bunds may be constructed at most suitable sites so that the out flow of the water will be checked (Fig. 1) for sustainable management of groundwater and hence for ecosystem development through ground water recharge.

ACKNOWLEDGEMENT

The author wish to thank Prof. (Dr.) M. Bhattacharya, Head, Department of Community Health Administration and (Prof.) M. C. Kapilashrami, Director, National Institute of Health and Family Welfare (NIHFW), New Delhi for inspiration and continuous encouragement. Dr. S. Mukherjee, Asstt. Professor, School of Environmental Sciences, JNU is also acknowledged for his valuable advice during the study.

KEY WORDS Urbanization. Industrialization. Hydro-mophogeology. Remote Sensing Data. Lineament. Groundwater.

ABSTRACT Geologically, the study area (part of South Delhi) falls in Delhi Supergroup quartzite terrain. Because of high demand of groundwater for domestic, agricultural, industrialization, urbanization and colonization purposes the water level in Delhi has highly reduced due to overdrafting in past few decades. Hydromorphogeology is directly related to groundwater availability. The occurrence and movement of groundwater is restricted to the buried pediment and

interconnected lineaments. Satellite Imagery (Remote Sensing data) provides excellent information for natural resources, ecological studies, hydromorphogeological studies and water resource management. Disused and active brick kiln areas are marked as semi-circular white patches in SPOT data which are devoid of vegetation. Repeated heating of these areas resulted change in texture of the topsoil that effectively reduces the groundwater recharge of the area due to altered soil properties. Remote Sensing data provide reliable and quick information about ground water potential areas. An approach to build check dams/ bunds for groundwater conservation has been suggested. Changed soil properties due to repeated heating favours succession of limited and selected shrub- & herbaceous species on disused brick kiln areas.

REFERENCES

Coleman, T. L., Ag`bu, P. A. and Montgomery, O. L.: Spectral differentiation of surface soils and soil properties: Is it posssible from space platforms? *J. Soil. Science Society of America*, **44:** 1282-1285 (1993).

Dey, R. C.: Geology, geomorphology and mineral resources of Khodana and adjoining areas (Haryana) and their significance in landuse planning. *Photonirvachak,* **13(1):** 57-66 (1985).

Dey, R. C. and Rao, R. B. S.: *Geology and Basemetal Mineralization in Khodana- Narnaul Area, Mahendragarh District, Haryana, XXVII IGC, Moscow*, V. VI, Sec. 12 (1984).

Jha, V. K. and Roy, A. K.: Remote Sensing for geology, morphology and lineament study of Vindhyan basin, north of Shivpuri, Madhya Pradesh. *Photonirvachak*, **13(1):** 39-47.

Krishnan, P., Alexander, J. D., Butter, B. J. and Hummel, J. W.: Reflectance techniques for predicting soil organic matter. *J. Soil. Science Society of America*, **44:** 1282-1285 (1980).

Manchanda, M. L. and Ravindran, K. V.: Groundwater investigations in Jawaharlal Nehru University Campus, New Delhi. *Unpublished Report of RRSSC, NNRMS, ISRO, Deptt. of Space. Dehradun* (1993).

Mathews, J. L.: *Application of Multispectral Remote Sensing and Spectral Reflectance Patterns to Soil Survey Research*. Ph.D. Thesis, Pennsylvania State University, University Park, P. A. (1970).

Sen, D.: Geomorphology of the Aravalli Range, Rajasthan and a reinterpretation of residual erosion surfaces. *J. Geographical Review of India,* **34(3):** 262- 286 (1972).

Yadav, S. K.: *Hydromorphogeological Studies in and Around South Delhi Using Remote Sensing Techniques*. Unpublished M. Phil. Thesis submitted to Jawaharlal Nehru University, New Delhi, India (1994).

Author's Address: **Surendra Kumar Yadav,** *Assistant Research Officer*, Department of Community Health Administration National Institute of Health and Family Welfare, Munirka, New Delhi 110 067, India
E-mail: sk_yadav11043@yahoo.com