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INTEGRATED APPROACH USING REMOTE SENSING AND GIS FOR HYDROGEOLOGY OF MORODA BLOCK IN MAYURBHANJ DISTRICT, ODISHA, INDIA

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Abstract

Due to the highly complex nature of both human and physical systems, the ability to understand them and model future conditions using a watershed approach has taken a geographic aspect. Satellite remote sensing and Geographic Information Systems (GIS) technology have played a vital role in all aspects of watershed management. For the study of hydrogeology of Moroda block of Mayurbhanj District Thematic maps are prepared by visual interpretation of SOI toposheets and linearly enhanced merged data of Landsat, Cartosat and LISS-III imagery on 1:50,000 scale using ERDAS and Arc GIS software. The main aim of the study involves compiling and analyzing all available data on hydro-geological framework of the block to assess its ground water development potential for improving socio-economic development of the block. By study we find that the entire block can be broadly divided into two distinct zones viz; tertiary formation and river alluvium. The hydro-geological setup and ground water development potential of these formation varies significantly from each other. The granular zone occurring under un-confined and semi-confined condition in the tertiary tract of the district can suitably be tapped through installation shallow tube wells as well as medium deep tube wells.

Keywords: *Remote Sensing; GIS; Hydrogeology; ERDAS and Arc GIS software*

Introduction

Water is an essential natural resource for sustaining life and environment. Remote sensing with its advantages of spatial, spectral and temporal availability of data covering large and remote areas within short time has become a very handy tool in assessing, monitoring and conserving groundwater resources. The Satellite data provides quick and useful baseline information on the parameters like geology, geomorphology, Land use/land cover, lineaments etc. controlling the occurrence and movement of groundwater [1].

In recently papers, some authors [2-5] have used the approach of remote sensing and GIS for identification of groundwater potential zones and exploration of groundwater with locating the artificial recharge sites. Also, other authors [6, 7] have used remote sensing and GIS techniques for delineation of groundwater potential zones and another scientists [8, 9] have used the remote sensing and GIS technique for generation of groundwater recharge zones map for the improvement and development of groundwater for the region. *J. Brema* and

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G.P. Arulraj [10] have used GIS for identification of sites suitable for artificial recharging and groundwater flow modeling.

The available water resources are under pressure due to increased demand and the time is not far when water which we always thought to be available in abundance and free gift of nature, will become a scare community. Remote sensing with its advantages of spatial, spectral and temporal availability of data covering large and inaccessible areas within short time has become a very handy tool in exploring, evaluating, and managing vital groundwater resources [11]. Satellite data provide quick and useful baseline information about the factors controlling the occurrence and movement of groundwater like geology, lithology, geomorphology, soils, land use/cover, drainage patterns, lineaments, etc. [12]. Ground water is attracting an ever-increasing interest due to scarcity of good quality sub-surface water and growing need of water for domestic, agricultural, and industrial uses. It has become crucial not only for targeting of groundwater potential zones, but also monitoring and conserving this important resource [13]. To meet the increasing demand the development of ground water resources has been considered way by all communities. The main aim of the study involves compiling and analyzing all available data on hydro-geological framework of the block to assess its ground water development potential. Total cultivable area of the block is around 102.01km^2, out of which nearly 30% of this area receives irrigation from different sources. Due to paucity of irrigation facilities in the block, the agriculture is mostly dependant of South-West monsoon. At present the stage of ground water development of the block is merely 30.72%, hence there is vast scope for ground water exploitation through installation of different ground water extraction structures to augment the irrigation potential. This is a basic requirement for improving socio-economic development of the block.

Location and Accessibility

The Moroda blocklying between the parallels Latitude 21º48’00 to 21º58’00 North and Longitudes 86º48’00 and 87º03’00 East has a gross geographical area of 342.19km^2 (Fig. 1). The block is largely represented by alluvial formations and is featured in Survey of India Toposheet No.73 K/13. The block is bounded by the Baripada, Betnoti and Suliapada block of Mayurbhanj district. As per 2001 census, the total population of the block comes to 94,015, out of which SC/ST population is 49,057 (52.18%) and rest general category population is 44,958 (47.82%). The Rural population of the block is nearly 99%. The total numbers of villages in the block are 169 out of which 6 villages are uninhabited.

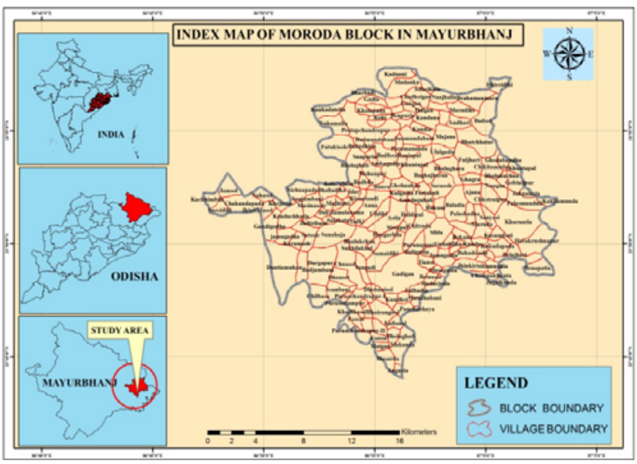

Fig. 1. Location of Moroda Block in Mayurbhanj

Methodology

The following hydrogeological survey and investigation works were taken up in the study area during the survey. The inventory of ground water extraction structures was collected. Ground water table was measured from different observation wells fixed in the study area and daily draw down due to pumping was ascertained. Geophysical VES test were conducted to ascertain type of aquifer, its areal extension and ground water potential. The Intensity and spacing of ground water structures in the study area and its impact on ground water table was studied. Data were collected from different agencies to calculate the ground water potential of the study area as per GEC norm. Hydro-chemical behavior of the ground water has been evaluated based on the analytical result of the water samples collected from the study area. Remote sensing and GIS approach was used to study the hydrogeology of the area (Fig. 2).

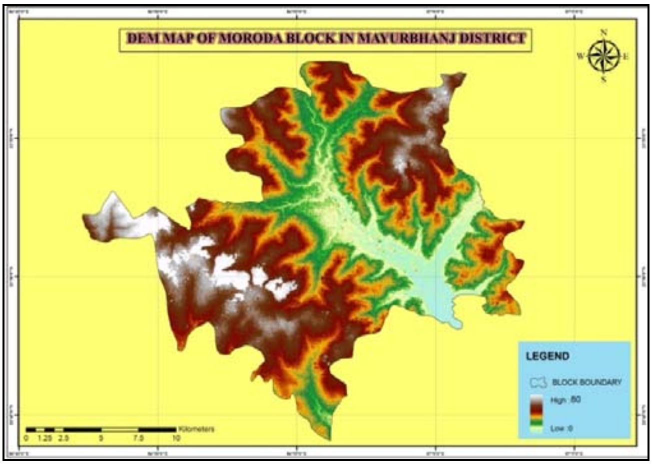

Fig 2. Digital Elevation Model (DEM) of Moroda

General Geology

Physiography

It is a well established fact that geological set up of an area plays a vital role in the distribution and occurrence of groundwater [14]. Physiographically the block represents tertiary plain. The general slope is towards east. This tertiary plain is fertile and is covered with moderate vegetation. The study area mostly stands between 20m to 82m. contours above mean sea level. A contour map of Moroda block is enclosed. Geomorphologically the block area comes under a Pedi plain with slope between 0 to 5 degree. The highest elevation of this block is 80m. Digital Elevation Model (DEM) map of Moroda block is enclosed.

Drainage system

The block is drained by a network of rivers and Nallas having flow in different directions. Jambhira is the principal rivers flowing through the block. The drainage density is observed to be fairly moderate and drainage pattern is observed to be dendritic in nature. A map showing the drainage of the block t is enclosed.

Rock Types

The block area is devoid of any major rock types. Baripada bed of Miocene age occurs to in this block built up by marine deposits in the form of continental shells. The literates of Eocene age are found overlying the others. Most part of the block area is covered by alluvium. A Geology map of Moroda block is enclosed.

Stratigraphy

The stratigraphical sequence of the area may be represented as follows.

Quaternary	Alluvium, sand, clay etc.
Early Pleistocene	Laterite, lateritic soil etc.

Geophysical Survey

Depth of occurrence of ground water zone and the location of well sites can be determined more effectively by electrical resistivity method. Integrated analysis and study, besides mapping and delineation of potential areas on small and regional scale help in determination of aquifer characteristics, flow pattern, and correlation of lithology [15, 16]. Geophysical resistivity survey and aquifer performance test were conducted to delineate groundwater potential zones in different parts of the block. The data collected have been analyzed and the following inferences are drawn. A thick clayey zone of about 10 to 40m serves as the top soil cover in the tertiary tract of the block. This is followed by occurrence of alternate layers of sand, clay and sandy clay of varied thickness.

The occurrence of basement has not been marked in course of exploratory drillings undertaken in the tertiary tract of the block. The thickness of topsoil cover (clayey zone) in alluvial tract is found to be varying from 10 to 30 meters. This is followed by occurrence of granular zones (sand and sandy clay) charged with fresh water. The occurrence of basement has not been marked in course of exploratory drillings undertaken in this tract. Data on Geophysical soundings conducted in Moroda block is given in Table 1.

Table 1. Data on Geo-Physical Sounding Conducted in Moroda Block

Sl. No	Name of the Block	Name of the Village	Type of Land	No. of layers interp-reted	Resistance observed in hm	Thickness of individual layers in meters	Lithology
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Morada	Nuasahi	High land	6	127.00	1.3	Lateritic soil
					190.50	3.38	Laterite
					18.88	11.44	Clay
					39.00	36.60	Sandy clay
					17.00	97.2	Clay
					39.00	Beyond 97.20	Sandy clay
2	- do -	Panchabhaya	Slopping land	5	480.00	0.50	Sandy loam
					25.26	3.00	Sandy clay
					60.00	1.70	Morrum
					26.00	105.00	Sandy clay
					17.32	Beyond 105.00	Clay
3	Morada	Mahalisahi	Low land	5	29.00	0.90	Sandy clay
					12.42	2.52	Clay
					60.00	3.30	Laterie
					10.00	44.00	Clay
					201.40	Beyond 44.00	Hard formation

Type of aquifer and its distribution

The ground water available in the block occurs both in unconfined and confined aquifers depending on the hydro-geological setup of the block. Detailed studies of the confined aquifers occurring in the block are yet to be taken up in systematic manner. In tertiary tract of the block, adequate thickness of granular aquifer (fine sand) occurs in both confined and unconfined conditions. The ground water occurring in granular aquifer is mostly found in semi-confined condition and ground water occurring in deep-seated aquifer is mostly found in confined condition. In alluvial formation of the block ground water occurs in the saturated pore spaces of the granular aquifers encounters at shallow depth under unconfined condition (Table 2).

Table 2. Litholog Data of Tube Wells in Moroda Block

Sl no	Name of the block	Location	Depth(in mtr)	Lithology
1	Moroda	Majhiani	GL-0.91	Clay
			0.91-4.57	Morrum

			4.57-9.15	Laterite
			9.15-19.82	Yellow clay
			19.82-24.40	Coarse sand
			24.40-25.60	Gravel with coarse sand
			25.60-27.45	Clay
2	Moroda	Karamsul	GL-6.10	Laterite
			6.10-9.5	Laterite and sand stone
			9.5-14.63	Yellow clay with sand stone
			14.63-21.34	Laterite and sand stone
			21.34-22.87	Coarse sand
			22.87-24.40	Sand stone
			24.4-25.92	Coarse sand and sand stone
			25.92-28.96	Yellow clay
3	Moroda	P.C.pur	GL-1.5	Surface clay
			1.5-20.74	Sandy clay
			20.74-28.97	Coarse sand
			28.97-32.00	Black clay
			32.00-35.07	Black coarse sand
			35.07-39.65	Black clay
			39.65-69.54	Black coarse sand
			69.54-88.45	Black clay

Ground water hydrology

Hydrogeologically the Moroda block comes under unconsolidated formation. Hydro-geologically the block has two distinct setups i.e. Tertiary tract and River alluvium. The alluvial plain forms the fertile part of the block and is covered with moderate vegetation. This tract comprises of alluvial deposit of varied thickness contributed by a network of rivers traversing the tract (Fig. 3). The general slope is towards North-South.

Water table fluctuation

The water table rises in the month of July, August and September, when recharge from rain fall exceeds withdrawals from wells and is maximum in the month of October. Water table is lowered during the winter and summer season due to withdrawal from wells, evaporation and discharge into streams and is lowest in the month of May and June. Fluctuations in water level indicate both changes in the actual quantity of water stored in aquifers and movement of ground water.

Taking into account data of observation wells situated in the block, it is observed that water table during Pre Monsoon varies from 4.5 to 11.0m and during Post Monsoon varies from 0.5 to 2.5m. The table showing present water table and Pre Monsoon, Mid Monsoon, Post Monsoon and Post Winter is enclosed. The study of hydrograph reveals that the trend of water table is unchanged.

Water quality

Water samples have been collected and analyzed in the hydro-chemical laboratory. In general it is observed that the ground water quality available in entire block may be used safely for irrigation and drinking purposes. A map showing chemical quality of ground water is Moroda block is enclosed (Table 3).

Table 3. Chemicals in Water Sample in Moroda Block

PARAMETER	VALUE RANGE
pH	6.81 – 8.75
EC (mhos/cm)	42 – 1850
TDS (ppm)	27 – 762
Ca^{2+} (ppm)	4 – 68
Mg^{2+} (ppm)	0.0 – 60.33
Na^{+}(ppm)	19 – 172
K^{+}(ppm)	0.0 – 58.3

Cl^-(ppm)	7.1 – 170.4
CO_3^{2-}(ppm)	0.0 – 24
HCO_3^-(ppm)	12.2 – 436.6
F^-(ppm)	0.0 – 1.9
SO_4^{2-}(ppm)	0.0 – 25.8
$NO_2^- + NO_3^-$(ppm)	0.0 – 25.8
TH(total mg $CaCO_3$/L)	5 – 420

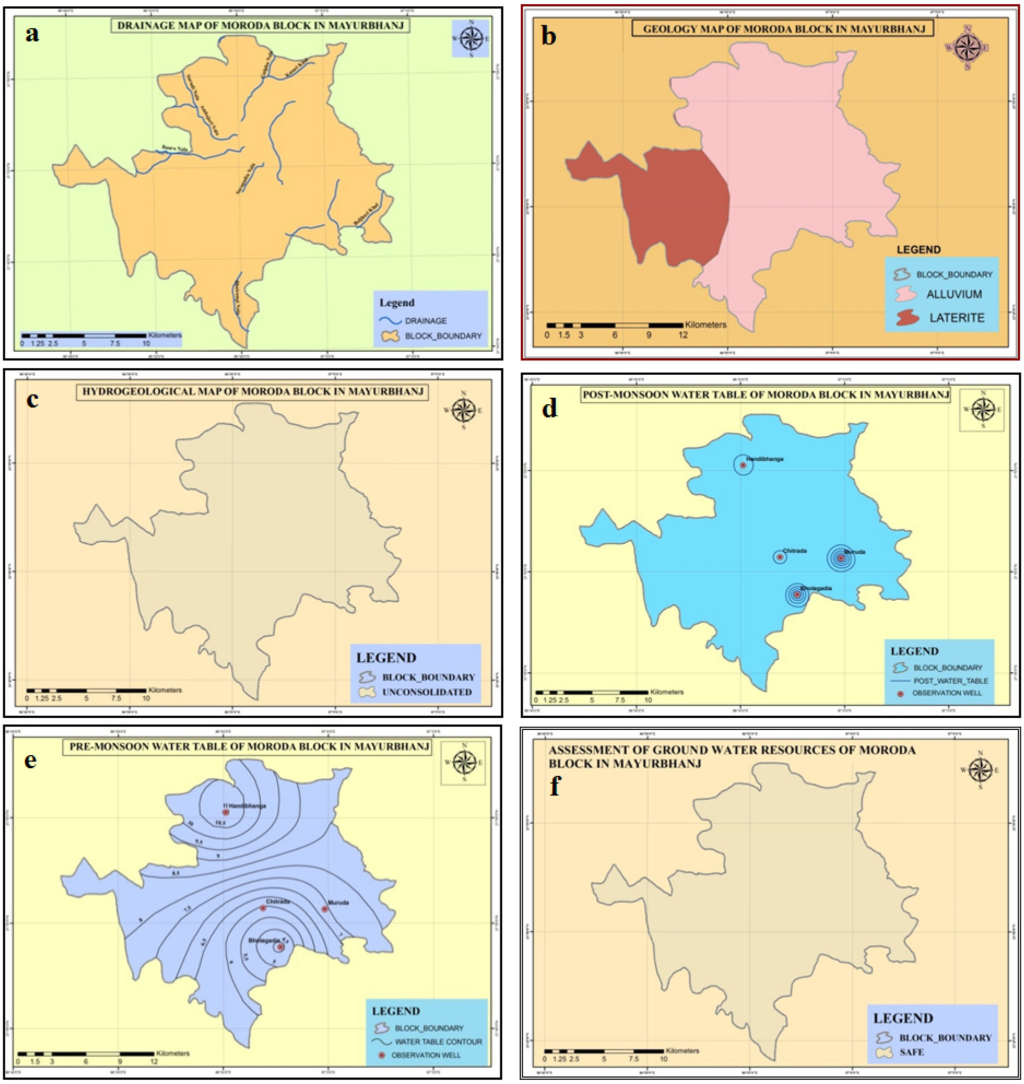

Fig. 3. Moroda block maps: a – drainage, b – geology, c – hydrogeology, d - Post-Monsoon water table, e- Pre-Monsoon water table, f - assessment of ground water resource

Assessment of ground water potential

The annual ground water recharge of a region largely depends on the hydro-geological setup and climatic conditions, more so on the precipitation it enjoys. As earlier mentioned, the ground water available in the block occurs both in un-confined and confined aquifers depending upon the hydro-geological setup of the Block. The ground water resources are occurring in un-confined only. The aquifers occurring at shallow depths both in alluvial and tertiary tract of the block are mostly un-confined in nature. The areal extension of such aquifers has been found to be 342.19km^2. The total annual recharge to the ground water body from all sources has been estimated to 7187hm. Out of this, the annually utilizable component of the ground water resources for irrigation purpose works out to be 6778hm. By now, nearly 2082hm of this key resource have been tapped through installation of 67 numbers. of medium deep tube wells, 188numbers. of shallow filter point tube well, 926 numbers. of dug wells with pump sets and 439 numbers. of dug wells with tenda (water lifting device). At present the stage of ground water development of the district is 30.72%. The overall ground water development of the district can be termed as safe category.

Conclusion

The entire block can be broadly divided into two distinct formation, tertiary formation and river alluvium. The hydro-geological setup and ground water development potential of these formation varies significantly from each other. The granular zone occurring under un-confined and semi-confined condition in the tertiary tract of the district can suitably be tapped through installation shallow tube wells as well as medium deep tube wells. Besides the above, the limited thicknesses of alluvial tract occurring along the rivers are found mostly suitable for installation of shallow tube wells and medium deep tube wells. The utilizable ground water potential available for irrigation has been estimated to be 6778hm (hectometer). By now nearly 2082hm of ground water have already been tapped through installation of 439 numbers. Of dug well with tenda, in traditional water lifting system, 926 numbers. Of dug wells with pump set, 188 numbers. of filter point tube wells and 67 numbers of medium deep tube wells. The ground water balance available for future development works out to be 4610hm.

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