IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Hydrological Parameters And Aquifer Studies In Bolangir District Of Odisha

Tarun Kumar Lohani[*1], Santosh Kumar Samantara[2]

[*1]Orissa Engineering College, Bhubaneswar, India

[2]Gop College, Gop, Puri, India

tklohani@gmail.com

Abstract

Bolangir is one of the severe drought prone and economically backward district of western Odisha, where average annual is scanty and erratic and the scope of surface water irrigation is limited resultingtosevere drought at times.Hydrology, georesistivity and exploratory drilling data were collected to find the soil type, rock structure and groundwater occurrences. It has been observed that, under favorable hydrogeological setup, the weathered and fractured rocks occurring at shallow depths provide good scope for storage of ground water. The weathered zones varies from 10 to 70 metre. These zones are generally encountered at a depth of 10 to 15 metre below ground level act as aquifer in consolidated formation. The weathered rocks occurring below the top of soil mantle together with fractured rocks serve as in ideal space for storage and movement of ground water. Semiconsolidated sediments like sand stone and shale belonging to lower Gondwana group are mostly seen in Agalpur block and act as good aquifer. Besides the above, weathered quartzite belonging to Cuddapah group of rocks, are also found in the Khaprakhol block. Some narrow strips of sandy aquifers are also encountered in the flood plains and in small valleys at close proximity of important rivers.

Keywords: Hydrology, aquifer, VES, Exploratory drilling.

Introduction

The study area lies between$20^0 9'$to $21^0 11'$N latitude and $82^0 41'$ to $84^0 16'$E longitude. Thedistrict boundary is confined by Baragarh district in the North, Sonepur and Kandhamal in the East, Kalahandi in the South and Nuapara district in the West.The geographical area of the district is 6571 km^2 is represented by an undulating topography with high hillock, forests, plateau, erosional plains and valleys. The district is divided into two distinct major parts, i.e. Hills of west and south and Plains of N-E.The Western and Southern regions of the district are occupied by hill ranges which gradually form a vast plain with bushy vegetation with isolated hillocks towards south. This tract is situated between altitudes 300 to 450 meter above mean sea level. The slopping erosional plain gives rise to stripes of plain cultivated lands, which are clearly distinguished. This tract is represented by an undulating topography with alternate high and low lands and isolated hill ranges mostly covered by thick forests. This tract is situated between altitudes 150 to 300 metre above mean sea level. The general slope of the area is in North-West to South-East direction with moderate gradient [3]. This facilities considerable weathering in the country rock and allows more penetration rain water to ground water storage.

Geomorpholgically,the area can be divided into three major parts i.e. pediments,valley fills and alluvial plains. Pediment is the most common unit having considerable thickness of weathered and fractured horizon. Valley fills are confined to surface depression, which are mostly covered by thin alluvium followed by weathered and fractured rocks. The alluvial plains occur as narrow stripes along the major rivers. Pediments and buried pediments in the foot hill region are found to have undulating topographic structures and slopping towards the main rivers [6]. The small hillocks and exposures are also occurring in this region. The erosional valley fills within the hills and hillocks are very common features in this region.

Geography, Geology and Geomorphology of the study area

[A] Drainage

The drainage system of Bolangir district is largely controlled by Mahanadi and its tributaries viz.Tel, Ong and Suktel.The general slope of the area is towards East and North with moderate gradient. The brief account of the important river basins and sub-basins occurring within the district are enumerated below. Tel is a major tributary of river Mahanadi. It

emerges from Titilagarh as river under and flows in South-East direction for about 130 km. and confluences with river Mahanadi at Sonepur.Ong is a major tributary of river Mahanadi. It arises from Agalpur block flows eastward for about 70 km and converges with river Mahanadi at Nandamal located at about 13 km from Sonepur.Suktel is originated from the Western plateau of Bolangir district and flows in Eastern direction for about 115 km. It meets with river Tel at Khaliapali of Sonepur block. The North Western part of the district is mostly drained by this river.

[B] Soil Type

Soil are the products of rock decay in which mechanical disintegration and chemical decomposition play an important role [7]. The nature of the soil depends basically upon the prevailing climate, quantity of rainfall, temperature condition, bed rock composition and topographic pattern. The dominant categories of soils encountered in Bolangir districts are shown in Table 1

Table 1 Soil type and their respective thickness

S.N	Soil type	Average thickness in m.	Place of Occurrence
1.	Light colored sandy soil	0.5 to 3.5	Loisingha, Agalpur Patnagarh, Muribahal area
2.	Loamy soil	2.0 to 4.5	In central part of the block
3.	Lateritic soil	0.5 to 2.5	Western part, Khaparakhol and Tureikela area
4.	Black sticky clay	0.5 to 4.0	North eastern part Agalpur, Loisingha, Puintala area

[C] Stratigraphy

Stratigraphic sequence of the district is represented in Table 2.

Table 2 Lithology of the study area including their geologic time scale

Sl. No	Stratigraphic Age	Lithology
1	Recent to sub-recent	Soil, Alluvium, Laterite
2	Intrusive (Igneous rocks)	Pegmatite & Quartz vein, Granite, Anorthosite
3	Gondwana Super Group	Shale, Sand stone, Conglomerate
4	Eastern Ghat	Garnetiferous Granite gneiss
5	Archaean	Charnokite, Pyroxene Granite, Khondalite, Calc Silicate, Granite Gneiss

[D] Well inventory

The data collected from the study indicate that in high land situations the fluctuation in water level is from 3.70 to 9.90 m. in summer, 1.70 to 7.60 m. in winter and 0.40 to 2.00 m. in rainy season bgl. And that in slopping land situation is from 4.10 m. to 9.30 m. in summer seasons, 3.40 m. to 6.20 m. in winter seasons and 0.50 to 1.45 m. in rainy seasons from bgl. In low land situation, the position of water level varies from 4.15 to 7.60 m. in summer seasons, 1.90 m. to 3.50 m. in winter seasons and 0.30 to 1.20 m. in rainy season from bgl.

[E] Geo-Resistivity Survey

In hard rock terrain, there is a good contrast in the resistivity values of bed rock, the fractured zone, weather zone and the top layer compromising of sandy and clayey materials. Resistivity soundings were conducted to fairly access the type of thickness of different layers occurring at a particular site and co-related with the lithology of nearest borehole and general geology of the area. Applying the knowledge of the hydrology of the area and available borehole data through exploratory drillings, it is possible to give a fairly accurate interpretation of the general sequence of the layers occurring in a particular site. Vertical Electrical Soundings (VES) were conducted in cultivable lands where ground water development would follow in due course [4]. The apparent resistivity values vary in order from 10^1 to 10^5 ohm-metre. In most cases, the thickness of topsoil varies from 0.6 to 9.40 m. followed by highly weathered rock of clayey nature from 1.1 to 20.80 m. This sequence is followed by hard rock with or without confining weathered and fractured zone in between. The places having adequate thickness of weathered (non-clayey nature) and fractured zones form good repository of ground water where bore wells may be successfully installed. From the interpretation of the sounding results, some locations are found to have good thickness of weathered zones [5]. The soundings have indicated in general, 3 to 4 layers sequence corresponding to the layers comparing of the soil, water bearing weathered zone. All sounding results show consistently increasing apparent resistivity zone extends up to a depth of 5 m. bgl in different topographic situations. The results of some soundings are given in Table 3.

Table 3 Resistivity and their respective thickness of different layers

Number of layers	True resistivity range in ohm-m.	Thickness range in m.	Probable lithology
Top layer	7.40 to 240	0.6 to 9.40	Sandy , ClayeyLoam
2nd	15 to 132	1.1 to	Highly weathered

layer		20.80	rock
3rd layer	51.4 to 945	3.5 to 71.50	Weathered/fractured rocks at places
4th layer	350 to 34650	Infinity	Hard base rock

[F] Exploratory drilling

Exploratory drilling operation undertaken in hard rock terrain provides positive data on sub-surface formations [1]. By now 10 nos. of exploratory boreholes have been drilled by GWSI department in the district. The depth of such exploratory boreholes ranges from 20 to 150 m. below ground level. The study of the drilling data reveals that the thickness of the top soil mantle varies from 1.52 to 13.1 metre below ground level. The weathered zone occurs at a depth of 4.5 to 15 metre below ground level. The weathered zone occurs at a depth of 4.5 to 15 metre below ground level. The thickness of weathered zone varies from 9 to 70 metre. Water bearing fracture zone usually occurs within 30 to 90 m. bgl. In Patnagarh block alluvial formations of 50 to 60 metre thickness have been encountered. In most cases weathered and fractured granite serves as main aquifer for the area. The water level pre to post monsoon periods. The depth of tube wells varies from 30 to 60 m.The discharge of the tube wells varies from 60 to 80 LPM. The water level in the above tube wells varies from 4 to 6 m.bgl during post-monsoon and pre-monsoon periods respectively [2]. Variation is the clear indication of lithologic control on groundwater occurrences [8]. The details of the exploratory drillings are given in the Table 4.

Table 4 Aquifer type and their thickness

SN	Type of Aquifer	Probable thickness In metre	Place of occurrence
1.	Sand	0.5 – 2.5	Narrow stripe along theRiver embankment
2.	Laterite	1.0 – 6.4	In the western part of District
3.	Sand stone ,Shale	2.5 – 45.0	Agalpur block
4.	Weather-ed granite Gneiss, Khondali te	18.0 – 71.0	Almost in all the blocks

Occurrence, distribution & movement of ground water

The formation of an area has a major role towards the occurrence, distribution and the movement of ground water. The area of Bolangir district comes under hard rock terrain. So the movement of ground water depends largely on weathering, fracturing and shearing of rock formations underneath. Most of the areas under the district are occupied by hard and compact crystalline rocks. These rocks are lack of primary porosity. After undergoing weathering and fracturing secondary porosity develops in these rocks. The occurrence and movement of ground water is mainly controlled by degree of weathering and fracturing as well as favorable topography on getting recharge mainly from rainfall [6]. Weathering of rocks basically depends on the lithological composition, texture and structure of the base rocks. The thickness and distribution of fractures influence the degree of weathering. Thick and extensive weathered zones under favorable topographic conditions get saturated from rainfall recharge and form good ground water repository which adds the source of ground water accumulation in the deep lying fractures. Granite gneisses are more susceptible to deep weathering and can form good aquifer in the weathered mantle whereas, weathered Khondalites are generally clayey which yield is very poor. Similarly massive and poorly fractured Charnokites and Quartzites are generally resistant to weathering and form erosional residuals.Alluvial fills in the flood plains, pediments and buried pediments in the foothill region and erosional valley fills within the hills. The alluvial fills are very much limited in the flood plains of the rivers and are found as limited patches along the river embankments.

Aquifer Characteristics:

The occurrence and movements of ground water largely depends upon the characteristics of the aquifer encountered in the area. This is also sometimes referred to as aquifer parameters. Pumping tests conducted at representative well locations give some realistic values of S, T & K. A few numbers of bore wells have been installed during recent past in the district. It has not yet been possible to conduct pumping tests in any of these bore wells. The process is still in the pipeline. The average permeability of weathered rocks decreases rapidly with depth. This decrease is largely attributed by the degree of weathering of parent rocks with respect to time and space. The aquifers encountered in such zones are mostly unconfined in nature.During the detail survey in some of the blocks of the district, 90 numbers of pumping tests have been conducted and the finding data have been analyzed. From the analysis of pump test and drilling data in basement rocks it is ascertained that basic inhomogeneity in the

aquifer characteristics mostly influence productivity of the aquifers and Granite gneiss has significant ground water potential because of its mineralogy and structure. On the basis of the data collected potential saturated fractures occur below 100 m. depth and in some cases occurs at a depth of 180 m. In other tracts low potential fractures occur within 60 metre.

Conclusion

The location of the observations well, depth of water table in both pre and post monsoon periods are analysed in details. Depth of water table as recorded from various observation wells indicate that in high lands the depth of water table varies from 5 to 10 metre during pre-monsoon period and 2 to 7 m. during post-monsoon period. In slopping lands it varies from 4 to 7.60 m. and 1 to 6.42 m. during pre and post-monsoon period respectively. In low land situations the depth of water table fluctuates from 3 to 6.20 m. and 0.50 to 3.00 m. during pre and post-monsoon period respectively.It is observed that rise of water level takes place during late June and reaches the peak during August. In high lands water level goes down beyond the total depth of some of the wells, resulting in drying up of the wells in summer. High water level fluctuations are noticed in some area. Recharge of ground water mainly takes places through rainfall. As there is very limited source of surface irrigation in the district except Agalpur block, the recharge from other sources like canals, return flow from irrigation water applied, seepage from tanks and ponds etc.are very much limited. Influence seepage from rivers and nalas also adds to the recharge to some extent. Hence rainfall has been considered to be the single largest factor in the recharge of the ground water body. The rainfall after contributing to surface run off, evapo-transpiration, evaporation etc. percolates through the loose soil mental and finally accumulates in the underlying weathered and fractured portion of the base rocks.The physical as well as chemical characteristics directly or indirectly depend on the geographical distribution, geological characteristics and climate of an area.The mineral contained in ground water is dissolved principally from the rocks and soil strata with which the water comes in contact. Hence the quality of ground water varies according to the variation of the rocks and soil strata. As far as the quantity of water resources is concerned, large section of people who mainly depend on groundwater draft get affected severely due to scarcity and untimely rainfall.

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