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# GROUNDWATER CONDITIONS IN A TRIBAL DOMINATED AREA OF MAYURBHANJ DISTRICT, ODISHA

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## ABSTRACT

The study area is located in the southern part of the Mayurbhanj district in the state of Odisha.. The geomorphic units of the area have been broadly identified as Lateritic upland, Alluvial plain, Flood plain, Residual Hills and Deeply weathered Pediplain. The predominant formation is in the form of older alluvium flanked by younger alluvium in the south east and consolidated formations in the North West top of which is partially lateritised. Ground water occurs under unconfined condition in the shallow weathered zone and circulates through fractures and joints. The thickness of the weathered zone varies from 3 to 35m. Depth of open wells in these formation varies from 5 to 14 meter below ground level. The occurrence of aquifer zones between 60 and 120 m depth is less frequent and normally one to three aquifer zones with the individual thickness varying from 4 to 12 m is found to occur. The ground water yield potential of this block is moderate because of the inherent formation characteristics and associated well construction difficulties in the absence of well defined pervious zones in many places. The stage of ground water development is quite high. However in certain instances, moderate to high yielding wells are encountered mostly in the older & younger alluvium. The area represents a typical tribal block sizable ST population and hence needs special care for sustainable ground water development along with equitable availability of water resources for the entire populace.

**Key Words** Hydrogeology,aquifer,sustainable,water table

## INTRODUCTION

Badasahi block is located in the Southern part of the Mayurbhanj District.. It is located within the latitudes of 21°35′32″ North to 21°53′55″ North and Longitudes of 86°35′16″ to 86°53′20″ East covering a total geographical area of 342.3 square kms. It falls under the Survey of Toposheet(1: 50,000 Scale) of 73 K / 9, 10, 13, 14. This is predominantly a tribal block having a sizeable ST population. Major problems reported by the people of the block are lack of proper irrigational facilities and scarcity of safe drinking water. The total population of the block is 130850 (2011 Census ) having a population density of approximately 382 persons per square km.

### Review of Literature

The literature available on ground water evaluation, development and management was reviewed in detail. Sikdar et al. (2007), Sankar and Venkatram (2002), Chauhan (2000) Rokade et al. (2007), Mahapatra et al. (2000), Patnaik(2003), Reddy et al.(2003), Sahu and Sahoo

(2006) and Sahu (2008). Choudhury et.al. in their study relating to ground water exploration and targeting potential ground water zone, have emphasized that integrated geological, geophysical, remote sensing and GIS techniques should be adopted for targeting potential ground water zones in hard rock areas. Reddy (1999) has emphasized the need to adopt modern know-how i.e. Remote sensing and GIS to evaluate the ground water potential in hard rock provinces. Josrotia and Singh (2007), Singh et al. (2007), Prasad (2007) and Pandian (2007) and Sahu (2003) studied on the hydrochemistry and ground water quality in different parts of the country and emphasized the need of qualitative evaluation for sustainable development of ground water resources.

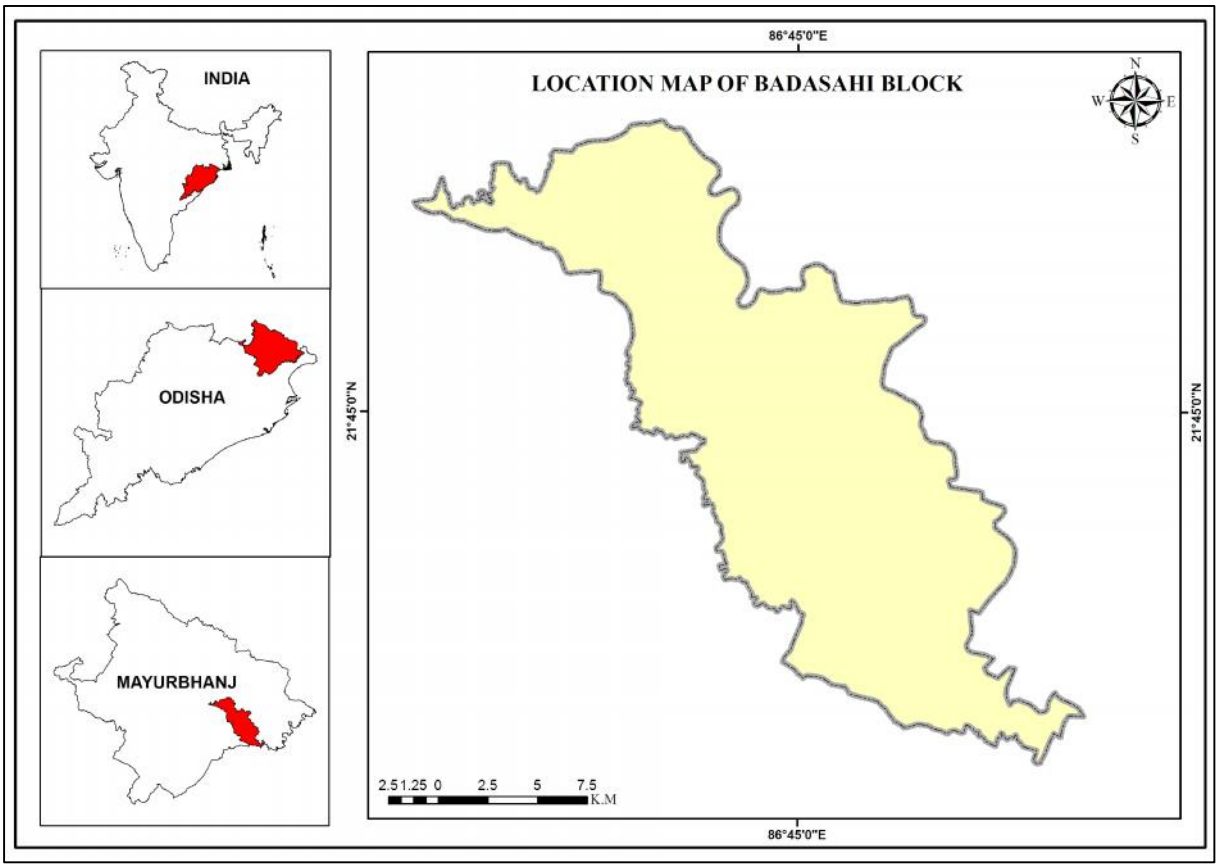


**Figure 1: Location map of the study area**

**Physiography & Climate -**The block is characterized by two distinct physiographic units. These are western hilly tract and Undulating plains. The undulating plains extending from the foot hills towards the east are characterized by gentle slope and endowed with most of the fertile and cultivable lands. The geomorphic units of the area have been broadly identified as - Lateritic upland, Alluvial plain, Flood plain, Residual Hills, Deeply weathered Pediplain. The area is drained by the tributaries of Budhabalanga, Kharkai, Jambhira. All these rivers and drainages exhibit dendritic type of drainage pattern and are structurally controlled. The climate of the study area is subtropical and characterized by hot summer, mild winter and well distributed rainfall. The summer season starts from March to middle of June followed by the Rainy Season from June to September and post-monsoon period during October and November. May is the hottest month with maximum temperature of 47°C and December is the coldest month with the minimum temperature of 6°C. The annual rainfall of the varies between 1343mm to 1855mm with the average of around 1585 mm. About 80% of the rainfall is received during south-west monsoon period. On an average there are 83 to 96 rainy days in a year. The air is dry during the greater part of the year. In the monsoon months from June to

September humidity is high which is on an average at about 60%. April and may are usually the driest months, where in the afternoon the humidity is less than 20%. On the average, humidity ranges from 19.0% in May to 71% in August in the morning and ranges from 45% in April to 85% in January in the evening. Winds are generally light during the post-monsoon and winter months. They strengthen a little during the summer and monsoon months. Winds are predominantly easterly and south easterly in the monsoon months. April to June is the period with highest incidence of thunderstorms. Rain during the monsoon months is often accompanied with thunder.

**Landuse, irrigation & agriculture** -The perusal of land utilization patterns reveals that the major part of the block falls under forest & green area. Agriculture and allied activities are the main occupation of the population. Paddy is the principal crop grown here. The area has also good production of food grains, cereals, oilseeds and other crops. The soils of the area may be broadly grouped into two categories depending upon their occurrence, physical and chemical properties e.g. Alfisols, Ultisols. Alfisols are distributed through out the area and includes older alluvial soil, red sandy soil and red earth soil.

**DATA USED & METHODOLOGY**

Collection of secondary data like population, rainfall, ground water abstraction structures and irrigation potential. Collection of Toposheets, references etc.Remote sensing technique has been adopted. Geological and hydrogeological maps have been used. Estimation of ground water resources using "water table fluctuation method" recommended by the Ground water Estimation Committee (GEC-1997) constituted by Govt. of India. In this method, the thickness of aquifer (T) is determined based on water table fluctuation recorded form the observation well. Specific yield(s) of each aquifer(s)/ formation are calculated by conducting pumping tests. By multiplying the aquifer thickness (T) with specific yield(s) of the formation and the rechargeable area (A) occupied by it, the gross ground water resource is worked out.. For estimation of ground water draft, unit draft method based on 100% well inventory has been utilized. The concept of ground water balance was introduced by the world bank. The ground water balance refers to the net ground water resources available for development in a given area, which is computed by subtracting the net ground water draft from the net utilizable. Systematic collection of 40 number of ground water samples from shallow and deeper aquifers during pre and post monsoon period and chemical analysis for ions like Ca, Mg, Na, K, $CO_3$, $HCO_3$, Cl, $SO_4$, $NO_3$ and other parameters like pH, Temp., TDS, EC etc. are measured. Geological field reconnaissance survey was made to collect field data in respect of lithology,structure,geomorphology ,weathering characteristics and water table position data.

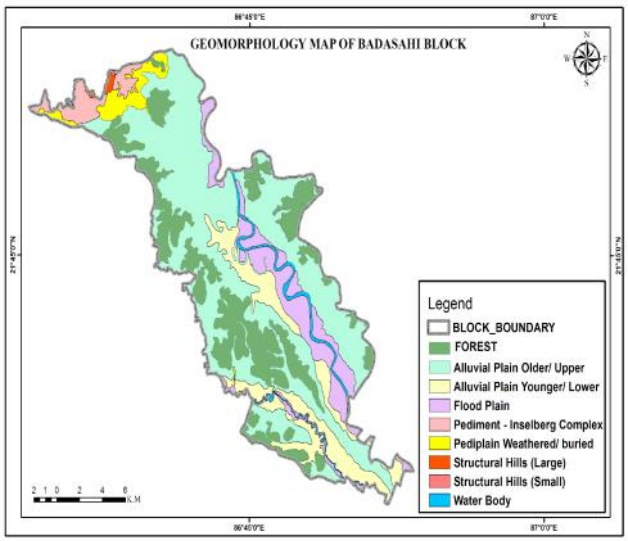


**Figure 2: Geomorphology map**

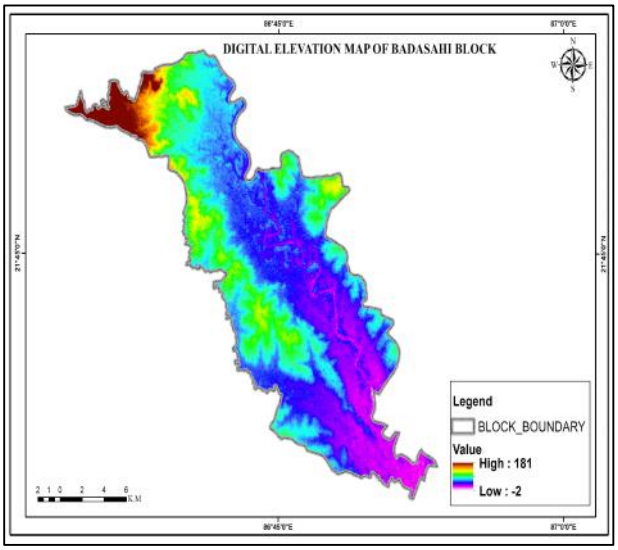


**Figure 3: Digital Elevation Model (DEM)**

## GEOLOGICAL SETTING

The Tertiary and Quarternary formations cover major parts of the study area. The Precambrain metamorphic rocks cover the western part of the area. The geological map of the study area is shown in figure 4. The generalized geological succession of the area is as follows.

| | |
|---|---|
| Quarternary | Alluvium and Laterite |
| Tertiary | Clay, Ferruginous grits, sandstones, sand, gravel And Limestones (Baripada Beds) |
| ~~~~~~~~~~~~~~~~~~Unconformity~~~~~~~~~~~~~~~~~~ | |
| | Newer Dolerite and Singhbhum Granite |
| | Soda granite, Granophyre and Gabbro anorthosite |
| | Dhanjori Stage: Dalma Volcanics and quartzite and |
| Precambrian | basal conglomerate |
| | Iron Ore series: Carbonaceous phyllite, mica schist, Quartzite with BHQ, Amphibolite |

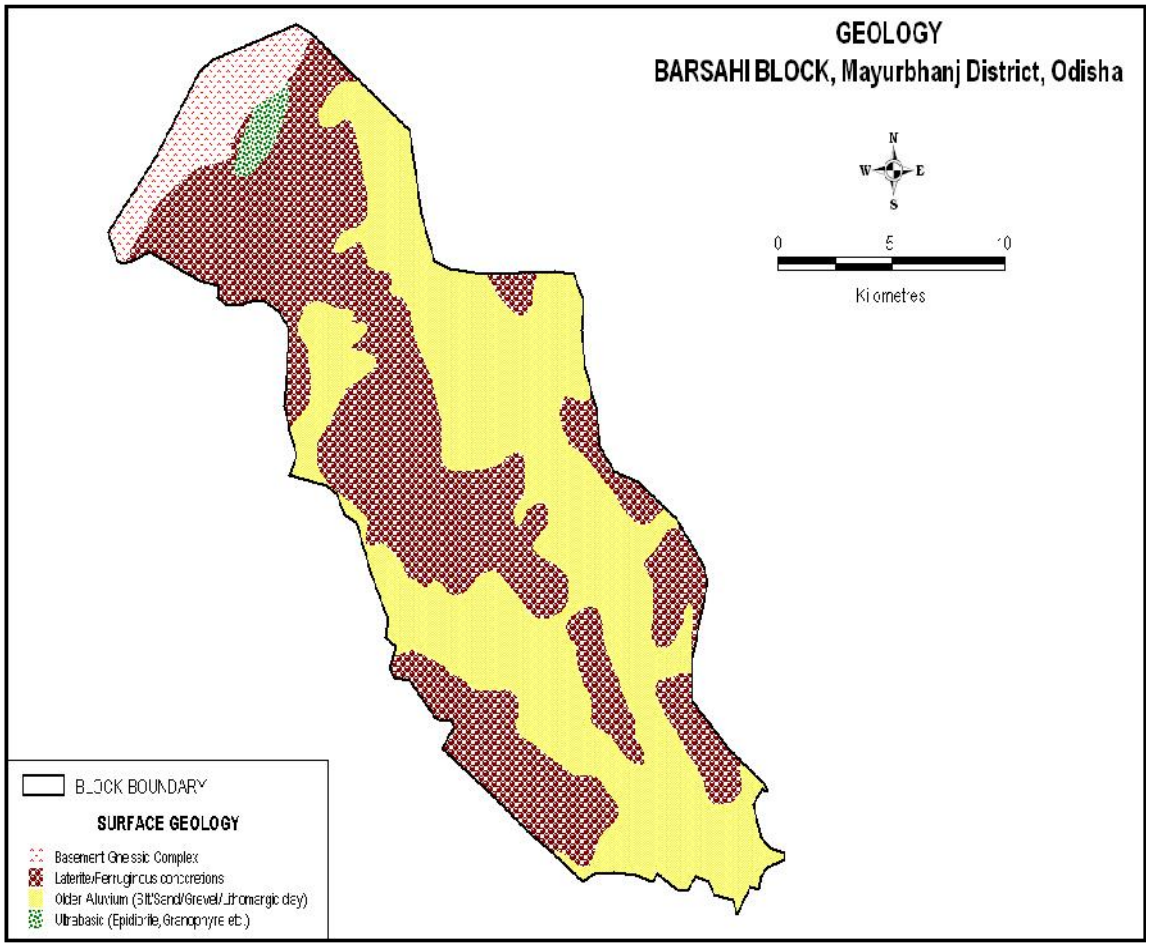


**Figure 4 : Geological map of the study area**

## HYDROGEOLOGY

The geological setup controls occurrence and movement of ground water in the area. The Pre cambrian crystalline and the intrusive are consolidated formations, devoid of primary porosity, but form aquifers when weathered and fractured. The tertiary formations are unconsolidated

with lateritic capping. They form potential aquifer and cover the majority of the area. The recent alluvium are unconsolidated, highly porous though of limited occurrence. Granites are one of the predominant rock types occurring in the undulating plains of the area. Ground water occurs under unconfined condition in the shallow weathered zone and circulates through fractures and joints. The thickness of the weathered zone varies from 3.5 to 36m. Depth of open wells in these formation varies from 6 to 14 meter below ground level. The depth of bore wells in these formation ranges from 45 -200 m below ground level. In these bore wells 3-4 water bearing fracture zones were encountered within the depth of 100m. The yield varies from 7 to 39 $m^3$/hr for a drawdown of 10-25m. The transmissivity value ranges from 4 to 58$m^2$/day. Tertiary alluviums consist of sand, clay, sandstone, fossiliferous limestone and gravel. With the sand and gravel layer sandwitched between the clay layers. Generally, the occurrence of aquifers(sand and gravels) are very common down to an average depth of 55/60m and within this depth the maximum cumulative thickness has been found to be 30m with the average thickness around 15 to 20m. On an average, the cumulative thickness of aquifers between 30 and 60m depth range varies from 6 to 12m.

The occurrence of aquifer zones between 60 and 120 m depth is less frequent and normally one to three aquifer zones with the individual thickness varying from 4 to 12 m is found to occur. The occurrence of sand and gravel zone below 120 m depth is rare but semi-consolidated clay layers containing considerable amount of sand and gravels act as an aquifer of low to moderate potential. The semi-consolidated clay layers with 30% sand and gravel occurring between 130 and 142 m depth recorded discharge to the tune of around 5 lps. No recoverable discharge is generally received from clay mixed with 20 to 30% of sand and or gravel occurring within 60m depth. The geophysical logging indicates that the formations below 120 m depth are in semi-consolidated form. The same sediments occurring under semi confined condition form deeper potential aquifers. Depth of the open wells in this formation ranges from 4 to 15m. The higher values of storage coefficient indicate that the aquifer are under unconfined to semi confined condition. On the other hand the low transmissivity values indicate that the aquifers are in general low yielding. The average cumulative yield is around 6 to 10 lps from the cumulative thickness of 30 to 40m of aquifer zones. This is because of semi consolidated nature of aquifer zones. The recent Alluviums composed of Sand and gravel layers form potential shallow aquifers. Ground water occurs under unconfined conditions. The depth of the dug wells ranges from 6 to 12m. The Ground water occurs under unconfined condition in this formation. In the laterites, the depth of the dug wells ranges from 3 to 22m and forms mostly the top perched aquifers. Considering all the facts the wells in Tertiary deposits of Mayurbhanj districts should not be drilled beyond 150m depth. The diameter of tube-well may be 152mm X 102mm (6inch X 4inch). The length of 152mm diameter hole may be 30 to 35m below ground level. The Hydrogeological map of the study area is given below in figure -5.

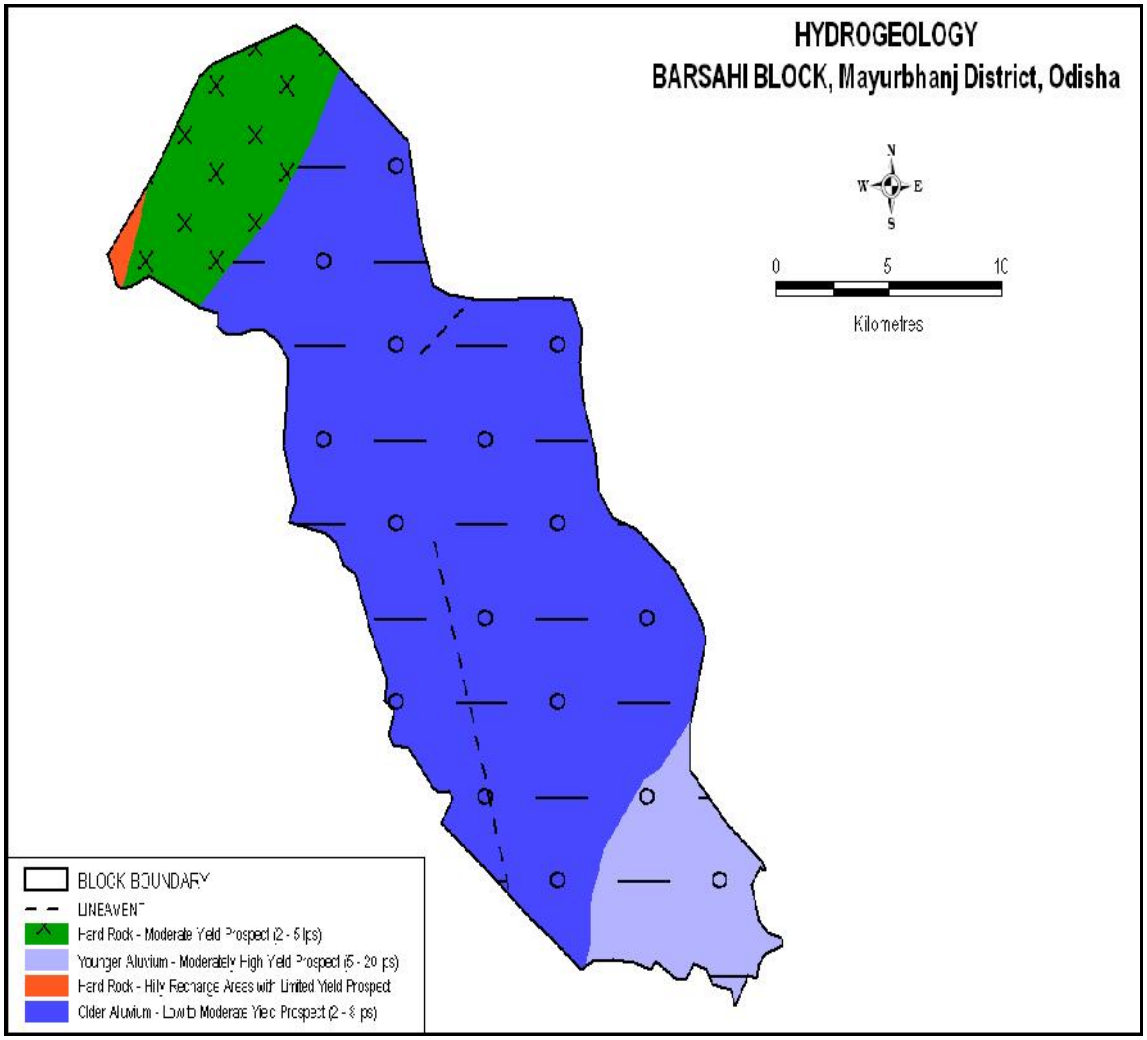


**Figure 5: Hydrogeology of the study area**

Three wells have been constructed in Badasahi Block to decipher the hydrogeological nature of the subsurface formation. As is evident from the previously discussed details on geology and hydrogeology, the major part of the district is underlain by un-consolidated formation of Miocene age, mostly classified as Tertiary Sediments popularly known as “Baripada Beds”. The details of the drilling data are given below in Table 1 .

**Table 1 : Details of Ground Water Exploration by CGWB in Badasahi Block**

| Sl No | Village | Depth Drilled(m) | Formation Encountered | Discharge (LPS) |
|---|---|---|---|---|
| 1 | Badasahi - 1 | 211.73 | Semi-Consolidated Tertiary Sediments | 18.0 |
| 2 | Kujidihi | 303.00 | Semi-Consolidated Tertiary Sediments | 5.5 |
| 3 | Badasahi - 2 | 211 | Semi-Consolidated Tertiary Sediments | 17.9 |

**Depth to Water Level**

The details of the wells and the depth to water level condition in pre and post monsoon period for the year 2015 is given below in table- 2 and the same is represented in graphical map in figure 6 & 7 respectively.

**Table 2 : Details of Depth to Water Level Data 2015**

| Sl No | Location | Depth to Water Level 2011 | | |
|---|---|---|---|---|
| | | Pre – Monsoon (mbgl) | Post – Monsoon (mbgl) | Fluctuation (m) |
| 1 | Belam | 6.23 | 4.57 | 1.66(Rise) |
| 2 | Manitri | 3.91 | 5.43 | -1.52(Fall) |
| 3 | Baliapal | 2.61 | 4.82 | -2.21(Fall) |
| 4 | Badasahi | 6.95 | 4.65 | 2.3(Rise) |

A perusal of the above data reveals that regionally there is no water logging in either pre or post monsoon season in the block. The fall of water level in a particular year may be attributed to the erratic and anomalous rainfall pattern on a local scale. Also the long term decadal water table trend shows that there is no significant decline in depth to water table in this particular block.

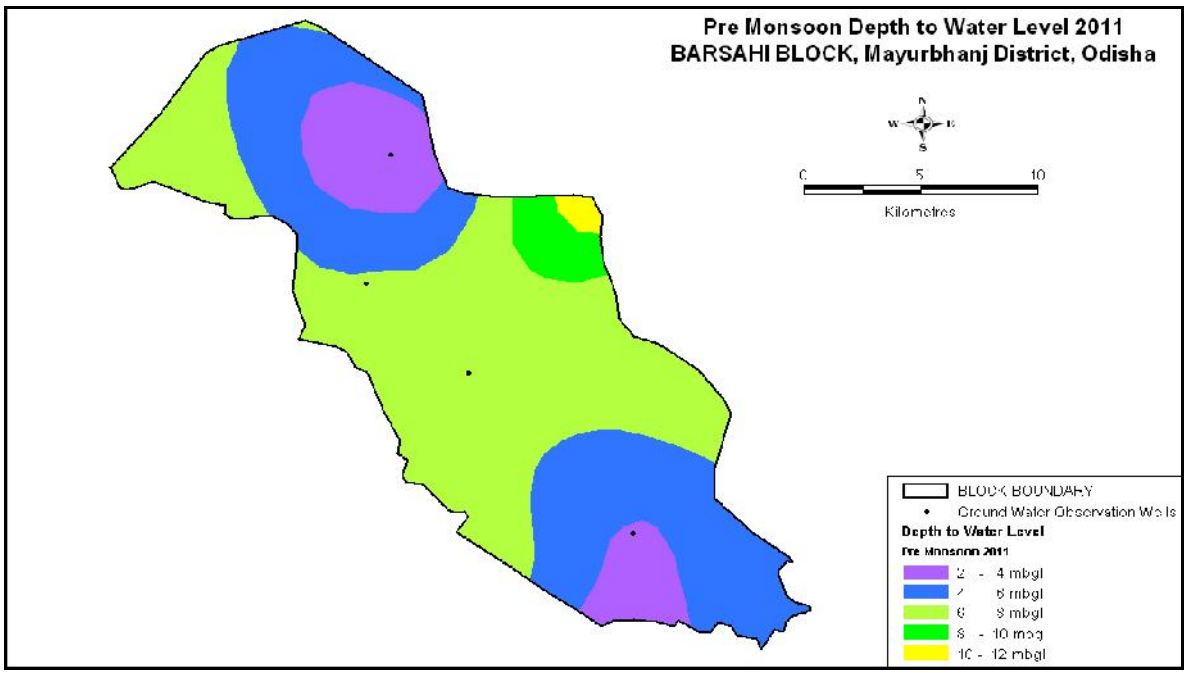


**Figure 6 : Pre Monsoon Depth to Water Level 2015**

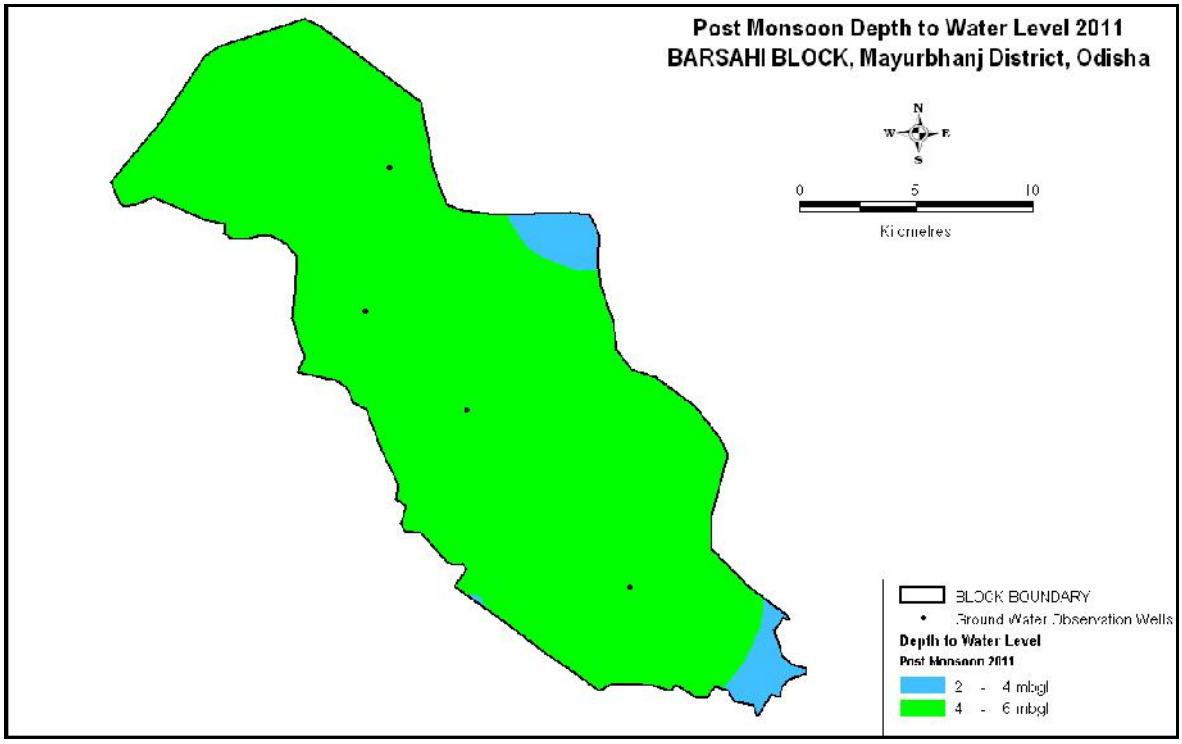


**Figure 7: Post Monsoon Depth to Water Level 2015**

**Groundwater Quality-** A perusal of analysis of water samples from both phreatic and deeper aquifers reveal that as a whole there is no problem with chemical quality of water samples. Almost all the water samples collected from the wells confirms within the BIS Standard (BIS:10500) for drinking water ( Table 3). There is no salinity, iron or nitrate problem in this block.

**Table 3 : Comparison of Ground water of the Block with ISI Standards**

| Chemical Parameters | Total No. of sample Analysed | Total No. of Sample within permissible limit | (percentage) |
|---|---|---|---|
| PH | 40 | 40 | 100 |
| TDS | 40 | 40 | 100 |
| TH | 40 | 39 | 97.5 |
| Ca | 40 | 39 | 97.5 |
| Mg | 40 | 40 | 100 |
| Cl | 40 | 40 | 100 |
| $NO_3$ | 40 | 40 | 100 |
| $SO_4$ | 40 | 40 | 100 |

**Table 4 : Range of Chemical constituents in ground water of the study area**

| Chemical Parameters | Concentration |
|---|---|
| pH | 7.0 – 8.5 |
| TDS | 162-1742 (ppm) |
| TH | 108-1342 (ppm) |
| TA | 65-412 (ppm) |
| Ca | 45-269 (ppm) |
| Mg | 1.5-105 (ppm) |
| Na | 78-389 (ppm) |
| K | 5-102(ppm) |
| $CO_3$ | 4-45 (ppm) |
| $HCO_3$ | 14-256 (ppm) |
| Cl | 68-1289 (ppm) |
| $SO_4$ | 12-156 (ppm) |

## Ground Water Resource Estimation

Ground water resource assessment is carried out as per the established norms of the recommendations of the Groundwater Estimation Committee (GEC), 1997. The assessment was carried out for the year ending 31st March 2015. The finding of Dynamic Ground Water Resources as on 31.03.2015 for the study area is given below:

| | | | |
|---|---|---|---|
| Annual Replenishable Ground Water Resources | : | 8198 | Hm |
| Net Ground Water Availability | : | 7739 | Hm |
| Ground Water Draft for Irrigation | : | 4675 | Hm |
| Ground Water Draft for Domestic & Industrial Uses | : | 328 | Hm |
| Gross Ground Water Draft for All uses | : | 5003 | Hm |
| Stage of Ground Water Development | : | 64.65 | % |
| Category of the Block | : | **Safe** | |

**CONCLUSION**

The study area is with a sizeable SC & ST population having problems of irrigational facilities and scarcity of drinking water. The ground water scenario in this area is quite favourable.Future scope of work exists for more detailed investigation and aquifer mapping to toposheet (1:50,000) level and possibilities of rain water conservation etc. can be explored further. The most suitable planning for the assured source of water supply round the year can be achieved by different types of groundwater structures like dug wells, dug cum bore wells and bore wells in favourable sites. Artificial recharge techniques play a major role for conservation of groundwater. The study area can be grouped into natural groundwater recharge zone based on the porosity, permeability and runoff characteristics of the land. Suitable sites for specific water harvesting structures/ artificial recharge structures such as percolation tank, check dam, gully plugs have been demarcated.Detailed ground water exploration with further smaller resolution and spacing may be carried out for additional input to the national aquifer mapping programme on 1: 50,000 scale. Scope for other detailed studies include detailed geophysical and hydro geochemical surveys with inputs from Remote Sensing and GIS studies for proper delineation and management of groundwater resources.

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