International Journal of Applied and Universal Research E- ISSN No: 2395-0269
Volume III, Issue 1, Jan-Feb. 2016 Available online at: www.ijaur.com

HYDROGEOLOGICAL SCENARIO AND WATER CONSERVATION MEASURES OF GARE - PALMA COAL MINING AREA, TAMNAR, DISTRICT-RAIGARH C.G

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ABSTRACT: The area is drained mainly by Kelo river and its tributaries namely Chini, Bendri, , Pajhar and Koledenga. Kelo river flows north to south direction in the central part of the study area Kelo river is a perennial river while rest of the tributaries are ephemeral in nature. This tributary system comes under Mahanadi basin. The drainage pattern in the area is sub-parallel and dendritic in nature with high drainage density indicating the formations in the area are moderatly porous & permeable in nature and are having high surface run-off. The drainage density is more or less same in the study area. Geomorphologically the study area comes under Structural Plain, Hills & Valleys and Pediplain/pediment. The Physiography of the basin is controlled by geological formations namely sandstone, shale, siltstone and coal seams.

KEYWORDS: Hydrogeology, Coalmine, Drainage.

INTRODUCTION

The occurrence of ground water is different in different formation and rock types which are based on the process of genesis and fractures/joints and cavities present in the rocks. The weathered and fractured zones present in the rocks or formation provides scope of ground water occurrence, storage and its movement. In the area, ground water occurs under phreatic or unconfined condition in weathered portion of rocks and semi-confined to confined conditions in deeper aquifer. For knowing the behavior of the ground water storage, depth to water levels and fluctuation, the water level monitoring was carried out in the study area by establishing 30 nos. of observation stations (Dug Well) at different villages within 10 km of radius during pre-monsoon and post-monsoon season (2010-11).

Location Details:

Gare-Palma coal mining area is South-Eastern Part of the Mand-Raigarh coal field. It is located about 27 km East of the Tehsil town, Gharghora and 55 km North-East of the District headquarters Raigarh. Area is falls under the Survey of India Toposheet No. 64 N/12.

The area is well connected by mettled and unmettled road as well as Rail networks. Raigarh Railway station, on Mumbai- Howrah Broad Guage main line of the South-Eastern-Central Railway is situated around 55 kms of the proposed project area. Raipur is nearest Airport and is about 215 km from the study area towards south-west. The location map of the study area is given in figure 1.

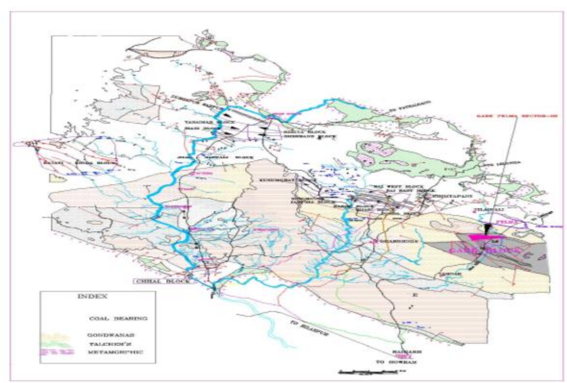

Fig. No. 1.1 location map

Geology:

In the area rocks of Gondwana Supergroup are mainly exposed. These rocks are of Barakar & Mahadeva formation which are represented by sandstone, siltstone, shale and coal seams. However, the generalized

Regional stratigraphic sequence of the area is given in Table 1 below:

Table-1 Regional generalized stratigraphic sequence of study area

Age	Super group	Group	Formation	Lithology
Quaternary	Recent to sub-recent		Alluvium & Laterite	Sand, Silt, Clay & laterite
Cenozoic	Trap & Infra-trappeans			
Carboniferous to Cretaceous	GONDWANA SUPERGROUP		Mahadeva Formation	Shale, Sandstone, Clay, silts
			Panchet Formation	Shale, arkosic Sandstone, Clay
			Kamthi Formation	Sandstone, shale, clay
			Barakar Formation	Sandstone, shale, clay and coal seams
			Karharbhari Formation	Sandstone, shale, clay
			Talchir Formation	Shale, clay, silt and sand with boulders
Proterozoic	Chhattisgarh Supergroup			
Archean	Basement crystallines			

The details of formations exposed in the study area are described below briefly.

A) Barakar Formation:

In the area Barakar Formation of Gondwana age are exposed in major central and northern part of the study area. The Barakars are represented by thick sequence (>500m) of sandstone, shale, claystone and coal seams. The Barakar are only coal bearing formation in the district. Many coalseams have been found in the area both in shallow & deeper zones. The Barakar sandstone/shale is semi-consolidated, horizontally to low dipping strata. The sandstone is arkosic in composition, fine to coarse grained, poor to moderately sorted. The shales are generally black and carbonaceous in nature.

B) Mahadeva Formation:

In the area Mahadeva Formation of Gondwana age is exposed in small part in southern portion of the study area. They are mainly represented by red & buff sandstone with some red clay & haematite. It is generally devoid of carbonaceous matter. Sandstones are coarse grained and tinted in various shades of red.

Structure:

The Mand-Raigarh basin is part of the Ib River-mand-korba master basin lying within the Mahanadi graben. In the Mand valley proper the coal measures lying between Kharsiya and Dharamjaygarh display a broad synclinal structure with its axis running just south of Sithra. The northern limb of the Mand-River basin is exposed to the north in the Sithra Dharamjaygarh area where the Barakar beds are found to strike broadly in a NW-SE direction from the Talchir contact.

The general strike of the formation is in the North – South direction in the North–Eastern Part. The same veers in the North–South–Eastern direction towards the centre and South–Eastern part. The formations dip at 1 in 20 gradients towards West and North–West.

Hydrogeology

The occurrence of ground water is different in different formation and rock types which are based on the process of genesis and fractures/joints and cavities present in the rocks. The weathered and fractured zones present in the rocks or formation provides scope of ground water occurrence, storage and its movement. In the area, ground water occurs under phreatic or unconfined condition in weathered portion of rocks and semi-confined to confined conditions in deeper aquifer.

For knowing the behavior of the ground water storage, depth to water levels and fluctuation, the water level monitoring was carried out in the study area by establishing 30 nos. of observation stations (Dug Well) at different villages within 10 km of radius during pre-monsoon and post-monsoon season.

The water levels in different seasons are presented in Table 2.

Table No.2

S. N.	Village	Spot height (mamsl)	Pre-monsoon depth to water level (mbgl)	R.L.of pre-monsoon water level (mamsl)	Post-monsoon depth to water level (mbgl)	Fluctuation (m)
1	Tamnar	245.00	14.00	231.00	6.00	8.00
2	Deogaon	240.00	4.40	235.60	1.00	3.40
3	Parigaon	270.00	6.00	264.00	2.50	3.50
4	Salihabhata	260.00	9.00	251.00	3.50	5.50
5	Kunjemura	262.00	6.00	256.00	3.10	2.90
6	Dolesara	280.00	8.50	271.50	4.00	4.50
7	Mundagaon	277.00	6.50	270.50	4.00	2.50
8	Bajarmura	305.00	8.30	296.70	3.20	5.10
9	Barkaspali	255.00	8.00	247.00	4.00	4.00
10	Raikera	325.00	7.00	318.00	3.20	3.80
11	Bichhinara	330.00	8.00	322.00	3.20	4.80
12	Rampur	300.00	6.00	294.00	3.10	2.90
13	Pelma	290.00	5.00	285.00	3.10	1.90
14	Urba	290.00	6.00	284.00	3.20	2.80
15	Semijor	340.00	6.50	333.50	3.10	3.40
16	Jaradih	325.00	8.00	317.00	3.00	5.00
17	Mulipara	290.00	11.20	278.80	8.65	2.55
18	Dhaurabhata	290.00	12.00	278.00	8.00	4.00
19	Amagaon	290.00	7.00	283.00	5.50	1.50
20	Gare	260.00	8.00	252.00	5.50	2.50
21	Tangarghat	300.00	7.00	293.00	3.30	3.70
22	Jhikabahal	280.00	9.30	270.70	4.00	5.30
23	Janjgir	290.00	7.20	282.80	3.20	4.00
24	Karakhol	290.00	5.50	284.50	4.70	0.80
25	Jharna	270.00	5.00	265.00	2.00	3.00
26	Mendra	292.00	7.00	285.00	3.00	4.00
27	Girsima	310.00	7.00	303.00	4.00	3.00
28	Dongamauha	290.00	7.00	283.00	2.50	4.50
29	Bankheta	270.00	11.50	258.50	3.50	8.00
30	Banijkhol	290.00	6.50	283.50	4.00	2.50

DEPTH TO WATER LEVELS & FLUCTUATION

From the Table 5 it is observed that, the depth to water levels in pre-monsoon period ranges between 4.40 to 14.40 mbgl. From Fig 6, it is observed that water level between 5 to 10 mbgl covers the major area followed by water levels between 10-15 mbgl along surface water divides in eastern part & western part of the study area. Shallow water levels <5 are observed in central & north-south part along river courses.

The depth to water levels in post-monsoon season ranges between 1.00 to 8.65 mbgl. It is observed that water level between 3 to 5 mbgl covers the major area followed by water levels between 5-8 mbgl along surface water divides in eastern part & western part of the study area. Shallow water levels <3 are observed in central & north-south part along river courses.

Based on the pre-monsoon & post-monsoon data water level fluctuation in the study area it is observed that in the study area water level fluctuation varies from 0.80 to 8.00 m. From Fig 8, it is observed that in most of the area water level fluctuation ranges from 2 to 4 followed by 4 to 6 m. Further, along river courses and its adjoining area shallow water level fluctuations <2m are observed.

Ground water table, flow and yield

The study of Hydrogeological area reveals that, the flow directions are of two pattern/directions i.e. in western part of the study area it is towards east, in eastern part of the study area it is in west direction which indicates surface water divides in the central part of the study area. This surface water divides or zone represents deep water levels. All the drainage present over the area is effluent in nature which indicates that during lean periods ground water contributes to the river. The water table elevation in the study area ranges between 230 to 330 m amsl. Southern part of the study area is having low altitude of water table elevation while water table elevation increases to the zone of surface water divide and in the northern & eastern part.

The gradient of water table is also variable. It is high near zone of surface water divides low in remaining part of the study area. Major portion of the area is having yield between 1 to 5 lps in the central & northern part covered by Barakar while 1 to 8 lps yield is present in comparatively small area in southern part of the area covered by Mahadeva formation.

AQUIFER SYSTEM AND AQUIFER PARAMETERS:

In the study area both shallow and deep aquifer occurs. They are described as follows.

a) Shallow aquifer:

The shallow aquifers of the study area occur within an average depth of 30m. They are composed of weathered mantle. The configuration of water table in the shallow aquifer follows the topography due to which the ground water movement is generally towards valleys or topographic low. The recharging bodies such as tanks, canals and streams also influence the occurrence and movement of ground water in shallow aquifers. The shallow aquifers of the area are mostly developed by way of dug wells in the area whose depth varies from 10 to 18 m. In general the yield of dug wells ranges from 25 to 40 m^3/day.

b) Deep aquifer:

Deep aquifer system in the area mainly formed by the Gondwanas Supergroup of rocks. The deep aquifers of the area are mostly developed by way of bore wells in the area whose depth varies from 100 to 120 m. In general the yield of bore wells ranges from 1 to 5 lps.

WATER CONSERVATION AND RECHARGE MEASURES

Management of water is one of the critical challenges in the open cast mining projects. This also required an in depth understanding of various water sources their capacities in time and space and seasonal variability. In the present project, the mining activities are directly linked with the evacuation of water from the mine pit and hence proper planning for utilization of water withdrawn from the pit as well as accurate assessment of storage volume are important steps. Further, the rainfall contribution to the mine storage also needs to be evaluated so as to plan the withdrawal as well as any water conservation and recharge plan.

Ground water withdrawal is also envisaged in the area so as to meet various requirements and hence there is need to take appropriate measures for augmentation of ground water sources so as to ensure sustainability. Rainfall is only source of water in the area; rainfall & evapotranspiration are two major factors controlling the quantum of rainwater available for recharge. The investigated area receives rainfall for just 50 to 60 days a year. Thus not only the total rainfall but also its availability is confined to few days during which entire water resources planning has to be done.

To minimize the effect on ground water status, it is necessary that ground water storage of the area must be augmented by rainwater harvesting so that the existence of industry does not adversely effects the ultimate ground water status.

The other important factors controlling the natural recharge to ground water are rainfall intensity, hydrogeology & depth of water level. It is observed that majority of rainfall occurs in 3-5 major storms lasting only a few hours. Natural recharge to ground water is further restricted due to impervious hard strata. Some of water, which infiltrates during rainy period, is entrapped in the soil and it never reaches the water level. This water is ultimately lost due to potential evapotranspiration. The rates of evapotranspiration (PET) are very high in the area. On an average, annual PET is higher than the rainfall in the area. Thus any artificial recharge by indirect techniques should be such that most of the water stored on surface is put to ground water within the shortest possible time to avoid losses.

Feasible Rainwater Harvesting System

Hydrogeologically the area is composed of hard rock and for artificial ground water recharge Injection wells & open wells will be most feasible recharge techniques. This will help in augmenting the groundwater storage around the tube wells and open wells so that they can sustain in long term.

Need for Rainwater Harvesting And Artificial Recharge

The growing concern of climatic change influencing the rainfall pattern and extremes has necessitated judiciously and efficient use of water resources as well as need to adopt suitable water conservation measures so that more and more water may be stored in times of water surplus for use in times of water need. Artificial ground water recharge and rainwater harvesting has emerged as promising and indispensable tools to achieve this goal. They are deemed as a new paradigm in water resources management that can ensure sustainable management of vital freshwater resources. There are overriding advantages of storing surplus water in subsurface reservoirs compared to surface reservoirs. As a result, artificial recharge projects not only serve as water conservation mechanisms but also help in overcoming problems caused by overdraft. In addition, it can reduce the vulnerability of natural ground water recharge to changes in the amounts/pattern of precipitation, which is most likely due to impending climate change. In many areas, high land costs and environmental problems encountered with large surface reservoirs have enhanced the attractiveness of artificial recharge as a means of regulating water supplies. The main interest in rainwater harvesting has been methods of collecting and conserving rainwater at an early stage in the water cycle to ensure the best use of rainfall before it runs away into rivers and ground water, or disappears as evaporation. The appropriate choice of rainwater harvesting and artificial recharge techniques depends on the amount of rainfall and its distribution, land topography, soil type, vadose zone thickness and its hydraulic characteristics, depth and type of aquifers, hydraulic parameters of aquifer systems, source and quality of recharge water, and socio-economic factors, among others; these factors tend to be location specific. Thus, the selection of water harvesting and artificial recharge methods strongly depends on local conditions, which calls for proper scientific investigations prior to the design and execution of artificial recharge and/or rainwater harvesting schemes. Water harvesting methods include such widely differing practices as 'rooftop water harvesting', 'land surface water harvesting' and 'ground water harvesting'. On the other hand, a variety of methods have been developed to artificially recharge ground water and most use variations or combinations of direct surface, direct subsurface or indirect recharge techniques. Commonly used artificial recharge techniques, however, are through drainage canals, from surface water bodies like ponds and lakes, recharge through pits/shafts and tube wells/ bore wells etc.

RESULT AND DISCUSSION

The area is drained mainly by Kelo river and its tributaries namely Chini, Bendri, , Pajhar and Koledenga. Kelo river flows north to south direction in the central part of the study area Kelo river is a perennial river while rest of the tributaries are ephemeral in nature. This tributary system comes under Mahanadi basin. The drainage pattern in the area is sub-parallel and dendritic in nature with high drainage density indicating the formations in the area are moderatly porous & permeable in nature and are having high surface run-off. The drainage density is more or less same in the study area.

Geomorphologically the study area comes under Structural Plain, Hills & Valleys and Pediplain/pediment. The Physiography of the basin is controlled by geological formations namely sandstone, shale, siltstone and coal seams. In the area rocks of Gondwana Supergroup are mainly exposed. These rocks are of Barakar & Mahadeva formation which are represented by sandstone, siltstone, shale and coal seams.

The Mand-Raigarh basin is part of the Ib River-mand-korba master basin lying within the Mahanadi graben. In the Mand valley proper the coal measures lying between Kharsiya and Dharamjaygarh display a broad synclinal structure with its axis running just south of Sithra. The northern limb of the Mand-River basin is exposed to the north in the Sithra Dharamjaygarh area where the Barakar beds are found to strike broadly in a NW-SE direction from the Talchir contact.

The general strike of the formation is in the North – South direction in the North–Eastern Part. The same veers in the North–South–Eastern direction towards the centre and South–Eastern part. The formations dip at 1 in 20 gradients towards West and North–West. In the area, ground water occurs under phreatic condition in weathered portion in shallow aquifers and semi-confined to confined conditions in fractured part of rocks.

The depth to water levels in pre-monsoon period ranges between 4.40 to 14.40 mbgl. The depth to water levels in post-monsoon season ranges between 1.0 to 8.65mbgl. Water level fluctuation in the study area varies from 0.80 to 8.00 m and there is no long term water level decline observed in the study area. The flow directions are of two pattern/directions i.e. in western part of the study area it is towards east, in eastern part of the study area it is in west direction which indicates surface water divides in the central part of the study area. This surface water divides or zone represents deep water levels. All the drainage present over the area is effluent in nature which indicates that during lean periods ground water contributes to the river. The water table elevation in the study area ranges between 230 to 330 m amsl. Southern part of the study area is having low altitude of water table elevation while water table elevation increases to the zone of surface water divide and in the northern & eastern part.

The gradient of water table is also variable. It is high near zone of surface water divides low in remaining part of the study area. Major portion of the area is having yield between 1 to 5 lps in the central & northern part covered by Barakar while 1 to 8 lps yield is present in comparatively small area in southern part of the area covered by Mahadeva formation.

In water conservation measures, selection of water harvesting and artificial recharge methods strongly depends on local conditions, which calls for proper scientific investigations prior to the design and execution of artificial recharge and/or rainwater harvesting schemes. Water harvesting methods include such widely differing practices as 'rooftop water harvesting', 'land surface water harvesting' and 'ground water harvesting'. On the other hand, a variety of methods have been developed to artificially recharge ground water and most use variations or combinations of direct surface, direct subsurface or indirect recharge techniques.

In the study area both shallow and deep aquifer occurs. The shallow aquifers of the study area occur within an average depth of 30m. They are composed of weathered mantle. The configuration of water table in the shallow aquifer follows the topography due to which the ground water movement is generally towards valleys or topographic low. The recharging bodies such as tanks, canals and streams also influence the occurrence and movement of ground water in shallow aquifers. The shallow aquifers of the area are mostly developed by way of dug wells in the area whose depth varies from 10 to 18 m. In general the yield of dug wells ranges from 25 to 40 m^3/day.

Deep aquifer system in the area mainly formed by the Gondwanas Supergroup of rocks. The deep aquifers of the area are mostly developed by way of bore wells in the area whose depth varies from 100 to 120 m. In general the yield of bore wells ranges from 1 to 5 lps. The aquifer parameters of the study area for deep aquifer the transmissivity ranges from 40-100 m^2/day and at favorable places it goes up to 200 m^2/day. The potential fractures for boreholes up to 120 mbgl depth in the area are recorded at various depths i.e. 60-65, 75-80, 90-95 mbgl and are 3 to 4 in numbers.

The quality of ground water in area is generally alkaline to near neutral in nature. All major ions are within the limits of Bureau of Indian Standards for drinking purposes as well as irrigation purposes. The ground water resources within 10km of radius estimated on the basis of norms as per GEC'97 indicate that the total ground water resource of the present study area is of the order of 3094 Ham while the net available ground water resources in the area are of the order of 2784.60 Ham. Gross ground water draft in the area is around 693.41 Ham while Balance ground water resources are 2091.19 Ham. The stage of ground water development in the area is around 24.90 % which comes in "SAFE" category.

Water accumulated will be evacuated and will be used for industrial, environmental & other uses as well as for recharge purpose. Further the annual loss of ground water is much lower than the annual ground water recharge, so no impact on ground water is anticipated. Beside this the radius of influence worked out in the area is around 450 m, therefore the impact of mining activity on ground water storage will be confined to maximum distance of 500 m from mine face and further away no change will occur. The rain water harvesting will be practiced in the mine area by providing arrangements to arrest the surface run-off from the ML area and diverting it to the pit prepared for collecting the rainwater. The rainwater collection pit will be around 3m deep and filled with charcoal and pieces of bricks to soak water and pass it to ground. After mining proceeds further, the mine sump will act as rainwater collection pit. The system will be maintained throughout the life of mine. After mining is over, the void left will be used as water reservoir that will also be a source of groundwater recharge.

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