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Hydro-Geological Inferences through Holistic Analysis for Hanp-Sheonath-Kaura Groundwater Basins in Block Bemetara, District Bemetara [CG]

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Abstract: ***Ground water scarcity for the area of study has SEMI-CRITICAL ground water development stage as -78.06 %, according to Central Ground Water Board [CGWB] in December 2015. The prevailing causes for the occurrence of ground water scarcity have been highlighted. The area of study is the part of Mahanadi river catchment possessing three closely connected ground water basins namely: Hanp, Sheonath & Kaura with average annual rainfall of about 1500 mm. The holistic analysis has been carried out on the basis of relevant literature review and scrutiny of latest dynamic ground water resource publication of CGWB with emphasis on terrain set up, geological and hydro-geological conditions. The quantitative scenario of ground water has been ascertained through aquifer disposition with geometry, recharge-discharge characteristics and hydrological gradient in relation to prevailing three surface streams in northern, eastern and southern portion of the area of study respectively. Two main types of aquifer- unconfined and confined have been revealed up-to depth of 200 m through Vertical Electrode Sounding configuration by Resistivity survey- as geophysical prospecting. The annual recharge-discharge and extractable ground water for different uses with future trend have been documented. The qualitative scenario of ground water has been explained through reasoning pertaining to genetic, anthropogenic manner. The degree of vulnerability of ground water has been obtained through seventeen standard water quality parameters corresponding to Hand pump, Dug well and Bore holes. The entire ground water basins have been evaluated into urban, sub-urban and rural activity along with agricultural characteristics of clay mineralogy. The ground water management strategies for the area of study has been suggested to bring back safe stage of ground water development below 65 % with emphasis on conservation of ground water as well as impletion of intensive rainwater harvesting structures, change in conventional crop pattern in-to less water requirement crop, drip irrigation and transfer of ground water through adjoining ground water basins having surplus ground water resources, without deteriorating their ground water scenario.***

1. Introduction

Ground water is the basic need of public for different utility purposes on account of its potable nature, presently. It is being scare also due to consequence of public related activities like: population growth, changing land-use pattern, besides more stress on irrigation cum conventional agriculture. The poor recharge characteristics and extensive draw-down [discharge] condition, lack of unified perspective in planning & bad management leads to 'Hydrological Poverty' in Chhattisgarh.Ground water scarcity refers to the volumetric lack of water supply, calculated as ratio of public water consumption to available water supply of adequate quality and quantity in a given area [5].

North Central Chhattisgarh Region of CGWB, Raipur has declared the area of study as SEMI-CRITICAL stage for ground water extraction as 78.06% in December 2016 [6]. It warrants for adaption of suitable water conservation plan and measure for public welfare in the area of study.

2. Area of Study

The part of block: Bemetara in district Bemetara [CG] is the area of study. It has geographic coordinates- latitude N 22° 35' to 22° 55' and longitude E 81°30' to 81°45'. It s bounded by three rivers along northern, eastern & southern boundary namely- Hanp, Sheonath&Kaura respectively. The area is mainly agricultural land, devoid of forest cover and occupies by urban, sub-urban and rural activities. It is approachable by Durg-Dhamda-Simga state highway 7. The nearest railway station is Tilda. The location map for the area of study is illustrated as Fig.1.

The area of study was the part of district Durg, prior to January 2012. It has agricultural production mainly rice, wheat and sugarcane. It has three ground water basins, overlain by southern portion of Hanp river along northern side, followed with western portion of Sheonath river towards eastern side and northern portion of Kaura river in southern side respectively. Overall, it belongs to Mahanadi river catchment with average annual rainfall of 1500 mm by south west monsoon.

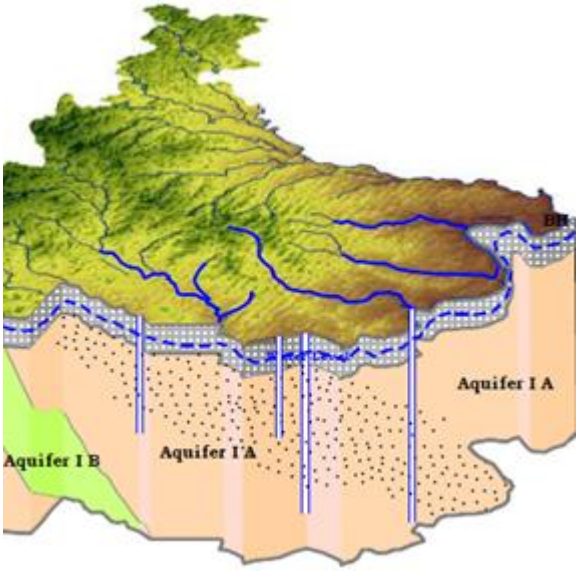

Figure 1: Location Map of the Area of Study

Evolved Methodology & Objectives

The evolved methodology is based upon conventional approach as Relevant Literature Review with scrutiny of latest annual CGWB report. The objectives of study are as follows:-

- Evaluation of Terrain set up
- Assessment of Geological condition
- Accreditation of Hydro-geological condition

3. Relevant Literature Review

The mode of occurrence and distribution of ground water horizon in the area of the study basically is governed by aquifer disposition with it's geometry, recharge-discharge characteristics besides hydrologic gradient along-with surface water- pond and streams. There are two types of aquifer namely unconfined at shallow depth and confined at deeper with respect to the depth criteria, conducted through Vertical Electrode Sounding up-to depth of 200m [6].

The shallow depth aquifers are being tapped through Hand pump, Dug wells with ground water fluctuation range 0.15-12.3 m. They dry up during pre-monsoon season. The deeper depth aquifers are being exploited through bore wells with ground water fluctuation range 0.85 -11.48 m. They face lowering of ground water table considerably during pre-monsoon season [4].

The dynamic ground water resource of district Bemetara during 2016-2017 has been summarized through eleven quantitative parameters and as follows [3]:-

- In Monsoon season, recharge from rainfall……=16640.00 BCM
- In Monsoon season, recharge from other sources……..=12525.56 BCM
- In Non-monsoon season, recharge from other sources… = NIL
- Total annual ground water recharge…… =43149.75 BCM
- Total annual natural ground water recharge…….= 4314.00 BCM
- Annual extractable ground water resource……=388834.78 BCM
- Annual ground water for irrigation……=28286.77 BCM
- Annual ground water for industrial……=44.59 BCM
- Total ground water……=30314 BCM
- Ground water allocation for domestic use in 2025……=2533.94 BCM
- Net ground water availability for future use…….. =7669.69 BCM

BCM= Billion Cubic Meter- unit for ground water quantity measurement by CGWB.

The area of study has two types of agricultural soil from ground water absorption point of view in term of clay mineralogy namely: Kaolinite& Montomorillonite. The Kaolinite rich area is characterized with low pH ground water content [less than 5-acidic] exhibiting pale yellow to red color soil on the ground surface. The Montomorillonite group is associated with shrinkage cum expansive character exhibiting black color. It has high saline ground water along paddy field [6].

The urban, semi-urban and rural activities in the area of study extract ground water through Hand pump, Dug well and Bore wells has low content of Biological Oxygen Demand [BOD] less than 2 mg/liter at certain places. It indicates that ground water is not suitable for drinking purpose [7].

4. Result & Discussion

Ground water regime for the area of study has been distributed in three ground water basins, depending upon prevailing three rivers namely Hanp, Sheonath and Kaura along northern, eastern and southern portion respectively. The percolation of surface water in-to sub surface is common along hydraulic profile of rivers horizontally and weathered formation, vertically. It is used to recharge unconfined aquifer. The quality of unconfined aquifer along Hanp ground water basin has lower content of Nitrite content due to anthropogenic activities and presence of grass and bushes on the surface.

The infiltration of rainfall is common along fractured formation in Sheonath and Kaura ground water basins. It is used to recharge confined aquifer. The quality of confined aquifer in Kaura ground water basin has higher content of sulfate due to genetic activities. The confined aquifer has been extensively tapped for paddy cultivation.

The aquifer mapping for the area of study deals with aquifer disposition, vertical and horizontal extent, recharge-discharge conditions. It provides ground water scenario, degree of vulnerability towards ground water quality and other related aspects through fulfilling the desired objectives as follows:-

a) Evaluation of Terrain set up

It is explained through prevailing surface drainage and geomorphic character for the area of study. The drainage density of all three stream sub-basins as surface drainage has low value as per interpretation of topo-sheet. It infers the plain nature of terrain with low run –off and high infiltration rate of water as governing parameters for ground water recharge.

It has two broad geomorphic unit namely Structural plain and Flood plain cum alluvium. The structural plain is associated with extensive cress-cross fracture and joints among shale- as major source of ground water occurrence cum movement in accordance with orientation hydrologic gradient. These features are responsible for quantity of ground water in confined aquifer. The flood plain is associated with orientation of river course in relation to alluvial deposit. It is responsible for quantity of ground water in unconfined aquifer.

It has average annual rainfall on the basis of rainfall occurrence in 2012, 2013 & 2014 as 1423.5 mm. The 95 % of it through south west monsoon during two months only July and August as natural recharge condition for recharge condition.

b) Assessment of Geological condition

Geologically, the area of study belongs to Proterozoic sedimentary province of central India. Maniyari formation – dominated with shale litho unit has been widely spread with elevation range of 30 m to 250 m. The deeper strata has occasional pocket of gypsum layer along solution activity among dolomite at the contact of shale. The shale formation has three stages namely: Weathered, Compact and Fractured with respect to increasing depth from the ground surface. The unconfined aquifer corresponds to weathered shale in association with alluvial deposit. The compact shale acts as impermeable zone in between unconfined and confined aquifer. The confined aquifer belongs to fractured shale. The gypsum layering at contact of fractured shale and dolomite along solution activity controls the sulfate concentration in ground water genetically-making it un-potable. It is required Reverse Osmosis [R O] plants for domestic water supply through Public Health Engineering Department.

c) Accreditation of Hydro-geological condition

Hydro-geologically, the area of study has aquifer disposition corresponding to weathered and fractured shale. The unconfined aquifer has been observed in Hanp ground water basin at shallow depth. It is recharged by percolation through alluvium along river regime. It is discharged through Dug wells, which often dry up during pre-monsoon season. The quantity of ground water for unconfined aquifer is governed by extent and geometry of weathered shale. The quality of ground water for the area has been controlled through grass and shrub occurrence and is being utilized for cattle grazing and animal drinking purpose.

The confined aquifer belongs to fractured shale horizon at moderate depth in Sheonath ground water basin. It is recharged by infiltration and discharged through Bore wells. It is underlain and overlain through compact shale. The ground water table lowering has been observed in the range of 3-8 m during pre-monsoon season. The ground water is being utilized for irrigation of Paddy, Wheat, Pulse, Tilhan, Fruits and Vegetables.

The deeper confined aquifer belongs to contact of fractured shale and dolomite in Kaura ground water basin. It is being used for Sugarcane cultivation, Food processing and Industrial units of small scale.

Ground water prospecting through Electrical Resistivity Survey with use of Vertical Electrode Sounding in the area of study has revealed three layered case for Kaura ground water basin as prominent zones at depth of 100 m, 120 m and 180-200 m. The two layered case has been also observed at depth of 100 m and 150 m in Sheonath ground water basin.

Ground water exploration as pumping test has been carried out in Hanp ground water basin. It has observed discharge rate of 18 liter /second with draw down of 2.32 m at depth zone of 18-21 m and 52-57 m from the ground surface.

The seasonal ground water fluctuation for shale [0.15-12.7 m] and dolomite [0.85-11.48 m] have been observed during pre-monsoon, monsoon & post-monsoon season of 2014. The ground water inventory has been conducted in Pre-monsoon season [May-June month], Monsoon [August month] and Post-monsoon [November month] respectively. The relevant information with range has been summarized as Table 1.

Table 1: Range of Ground water Inventory for the area of study

S N	Name of Ground water Basin	R L [m]	Total Depth of well [m]	Measuring Point [m] at Ground surface	Ground Water Level [m] in Pre-monsoon	Ground Water Level [m] in Monsoon	Ground Water Level [m] in Post-monsoon
1	Hanp	260-290	8.80-13.30	0.25-0.50	6.7-8.2	2.9-3.0	2.6-2.8
2	Sheonath	255-295	13.30-14.50	0.50-0.90	8.5-10.8	2.4	2.2-2.6
3	Kaura	260-310	12.80-14.50	0.45-0.60	10.8-10.9	2-6	2.2-3.1

The ground water quality scenario for the area of study during Pre-monsoon season has been studied through Dug well, Hand pump and Bore well. The in-situ information for Temperature and Acidic-Alkaline [pH] has been collected through Digital Thermometer, Ph meter. The remaining fifteen[15] water quality parameters is sterilized in oneliter bottle for Lab analysis through standard procedure [1]. Total seventeen [17] parameters have been correlated with World Health Organization [WHO] guideline [8]. The details are summarized in Table 2.

Table 2: Ground water quality scenario for area of study

S N	Ground water Quality Parameter	Unit	Hand Pump	Dug well	Bore well	W H O Standard
1	Temperature	0 C	18.44-28.42	19.73-30.58	19.36-28.56	15-31
2	pH	Nil	7.53-7.88	7.34-7.74	7.32-7.65	6.5-8.5
3	Alkalinity	Mg/l	83-112	92-117	60-85	N A
4	Total Dissolved Solid [TDS]	Mg/l	152-180	158-187	156-182	500
5	Free Carbon di-oxide	Mg/l	21-25	17-23	15-18	N A
6	**Biological [BOD] Oxygen Demand**	**Mg/l**	**1.8-5.7**	**2.1-4.6**	**2.0-3.9**	**2.00**
7	**Chemical COD] Oxygen Demand**	**Mg/l**	**9.6-15.6**	**9.1-12.1**	**8.7-14.2**	**10.00**
8	**Dissolved Oxygen[DO]**	**Mg/l**	**3.1-5.1**	**2.9-8.6**	**3.4-8.1**	**4.00**
9	Total Solid [TSS] Substances	Mg/l	15.2-21.2	23.0-37.0	24-33	50
10	**Chloride**	**Mg/l**	**273-458**	**230-270**	**240-330**	**250**
11	Calcium Hardness	Mg/l	21-43	28-41	22-38	200
12	Magnesium Hardness	Mg/l	25-44	19-36	25-40	50
13	Total Hardness	Mg/l	156-193	172-148	167-176	500
14	**Nitrite**	**Mg/l**	**0.6-0.9**	**0.5-0.8**	**0.6-0.8**	**45**
15	Iron	Mg/l	0.5-0,7	0.5-0.7	0.5-0.6	0.01-0.5
16	Phosphate	Mg/l	0.63-0.08	0.68-0.48	0.6-0.9	N A
17	Sulfate	Mg/l	5.5-7.8	6.2-8.8	5.4-7.4	20.0

5. Conclusion

The area of study belongs to SEMI-CRITICAL stage for ground water development. It is due to [a] drying up of river bed during pre-monsoon season, [b] lowering of ground water table in Bore well during pre-monsoon season, [c] excessive draw down due to heavy pumping on account of available electricity at subsidized rate during post-monsoon season and [d] 95 % of rainfall occurring in July & August months due to south west during monsoon season.

The ground water management strategies for the area of study in order to achieve **SAFE** stage [65 % ground water development stage] are as follows:-

- Conservation of ground water through grey water management under Jal Jeevan Mission.
- Conservation of ground water for irrigation purpose through enhancing drip irrigation, change in conventional cropping pattern for growing less water consuming crop and recycle of waste water.
- Rainwater harvesting in such area possessing more than 5 m ground water table in post- monsoon season through efficient check dam, percolation tank and nalla bund.
- Transfer of ground water through adjoining locality as Simga, Naigarh, without deteriorating their ground water reserve in respective groundwater basins.
- BOD,COD,DO & Nitrite are in critical range as per water quality sample analysis and need to be studied separately with more stress on their hydro-geochemistry in order to maintain potable nature of ground water for shallow to moderate depth.
- Sulfate in aquifer of higher depth should be examined for its utility in sugarcane growth [cash cum high water yield crop] and Food processing small scale industrial units from public health point of view.

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