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Original Article

Open Dug Well Data Analysis of Hyrdogeological System in Thandla Vicinity of Jhabua Region, Madhya Pradesh, India

Anil Katara[1], Vinita Kulshreshtha[2], Pramendra Dev[3,]*

Author's Affiliations:
[1]School of Studies in Earth Science, Vikram University, Ujjain, Madhya Pradesh 456010, India.
[2]Department of Geology, Rajiv Gandhi Government P.G. College, Mandsaur, Madhya Pradesh 458001, India.
[3]House No. 9, Adarsh Vikram Nagar, Ujjain, Madhya Pradesh 456010, India.

***Corresponding Author: Pramendra Dev**, House No. 9, Adarsh Vikram Nagar, Ujjain, Madhya Pradesh 456010, India.
E-mail: drpdev@yahoo.com

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ABSTRACT

The paper is focused on analysis of hydrogeological system of Thandla area, located in Jhabua district of Madhya Pradesh, India. Thandla region is characterized by geological formations of Aravalli super group, Deccan Traps with Quartzite, Phyllite, Alluvium and Soil. Thandla study area is mainly covered by Deccan Traps with Quartzite and Phyllite of Aravalli Super group. Alluvium is well exposed along the course of Padmavati River. The rest of Thandla area is occupied by Deccan Traps with Limestone, Sandstone of Lameta and Bagh beds in the lava flows of Deccan traps. The well inventory of 197 open dug wells helped in the identification of 35 observation wells. The measurements of observation well data point out a diameter range from 5.55 to 11.54 m., total depth of wells vary from 5.10 to 16.00 m.b.g.l., and static water levels range from 1.70 to 14.0 m.b.g.l. The seasonal monitoring of water levels indicate a fluctuation range of 1.3 to 11.0 m.b.g.l. Ground water level contour maps of the post- and pre-monsoon periods indicate that in general, the ground water movement is towards the Padmavati River. In the study area, at Manpur, Khandan, Rupgarh, Prwalya, Warlipara, Jamuri, Kakarej, Miyati, Munjal, Panchpiplya, Dhamni Chhoti, Chainpuri, Machhlaimata, Kundla, Madalda, Karikurna, and Etankhera is characterized by fairly good yield of water in dug wells during even pre-monsoon period . A few number of wells become dry during pre-monsoon period at villages of Angliyapara, Bahadurpara, Kaldela, Lalgarh, Berawa, Koriyapara and Dhawrapara. In general, movement of ground water is towards the Padmavati River. Ground water potential site have been recognized in the study area.

KEYWORDS: *Dug well, data analysis, Hydrogeological system, Thandla area, Jhabua region, Madhya Pradesh.*

1. INTRODUCTION

Hydrogeology has been considered by a number of workers as the science of occurrence, distribution and movement of water below surface of earth. It is a general term for water of earth that refers to distribution and movement of ground water in soil and rocks of earth. Meinzer (1923) described Hydrology as a science, which relates to water of earth. Water may be divided into three parts, which occurs in atmosphere, surface of solid part of earth, and below earth's surface. Water below surface can be divided into two parts that occurs in interstices of rocks and other part is supposed to occur in earth's interior, where interstices cannot exist because weight of overlying rocks and water. Tolman (1937) remarked that hydrogeology as all sciences, and geology is of greatest importance that deals study of sub-surface water. Hence, Hydrogeology deals with the presence, circulation, and flow of ground water.

Todd (1959, 1980, 2010) described hydrogeology as a science of occurrence, distribution and movement of water below surface of earth. Davis and De wiest (1966) remarked that Geohydrology has an identical connotation, and hydrogeology differs only by its greater emphasis on geology. Hydrogeology deals with geological conditions governing occurrence and movement of ground water, which occurs in cavities and spaces in rocks. Todd (1980) affirmed that an increase in the emphasis on hydrology, the subject is coined as "Geohydrology" Raghunath (1982, 1985). Karanth (1994, 2003) remarked that the general flow of fluids such as water, water, hydrocarbons, and geothermal fluids in deeper formation are also concern of the geologist, geophysicists and petroleum geologist. Todd and Mays (2005) have considered that Ground water hydrology is a science of occurrence, distribution, and movement of water below surface of earth. Geohydrology has a similar relationship and hydrogeology differs by its important stress on geology. Consumption of ground water dates from ancient era, while an understanding of the occurrence and movement of ground water in the hydrologic cycle.

Location and Physiographic Features of Study Area

The present study area is located in the Thandla tehsil of Jhabua district, Madhya Pradesh, within the Latitude 23^0 0′ to 23^0 10' N and Longitude 74^0 30' to 74^0 40' E, Survey of India Toposheet Number 46 I/12, (Figure 1) in Thandla area, Jhabua district, Madhya Pradesh. The present study area extends over 366.58 sq. km. The present area is located at a distance of 5 km South of Thandla road railway station (Western Railway).

The study area is approachable by both road and rail throughout the year. Physiographic features of study area are developed due to the denudation brought by the water and wind and area is divided into three physiographic regions namely, Hilly Terrain, Undulating country, and Plain country. Climate of the area is of tropical - monsoon type. Temperature ranges from 6^0C to 46^0C. Usually, study area is mainly dry. In general, inhabitants of Thandla study area enjoy monsoon season and experience as happy. Annual rainfall ranges from 423.00 to 2086.20 mm, with an average of 964.324 mm. Relative humidity is recorded as 34.4 to 50%. Study area is characterized by the presence of Quartzite, and Phyllite are developed in the Padmavati River basin. Basaltic lava flows having joints, fractures with different black cotton, lateritic, and alluvial soils.

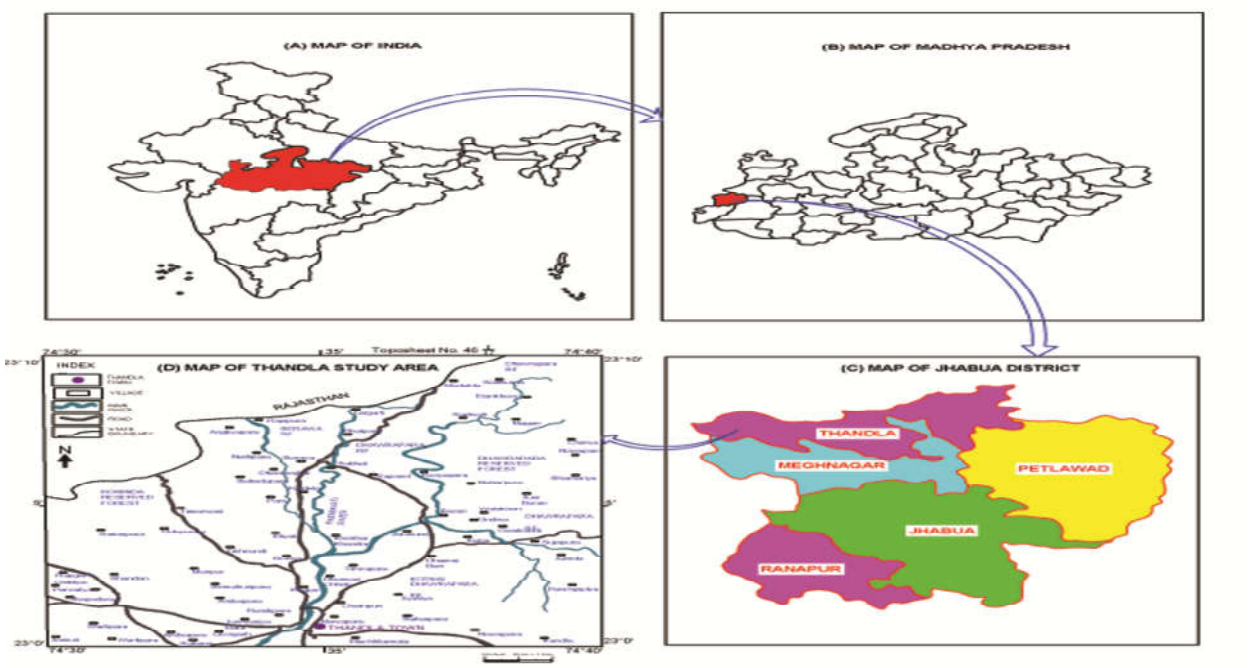

Figure 1: Location map of Thandla study area, Jhabua district, Madhya Pradesh, India (www.Google.com).

Geological Setting of Thandla Area

Geology plays an important role in the ground water exploration. The field setting of various rock formations, their lithological and structural features controls the hydrological conditions, landforms, drainage patterns and inflow of water into the sub-surface. Rock types such as Quartzite, Phyllites and others dominate geological features. These rock types have similarity with the Aravalli Super group (Archaean) of Rajasthan. Three Lava flows of Deccan traps have been observed in the Thandla area on the basis of characteristic features (Figure 2). Lava flows belonging to the Deccan Traps are dominant unit in study area. Black cotton, Lateritic and alluvial soils are well developed.

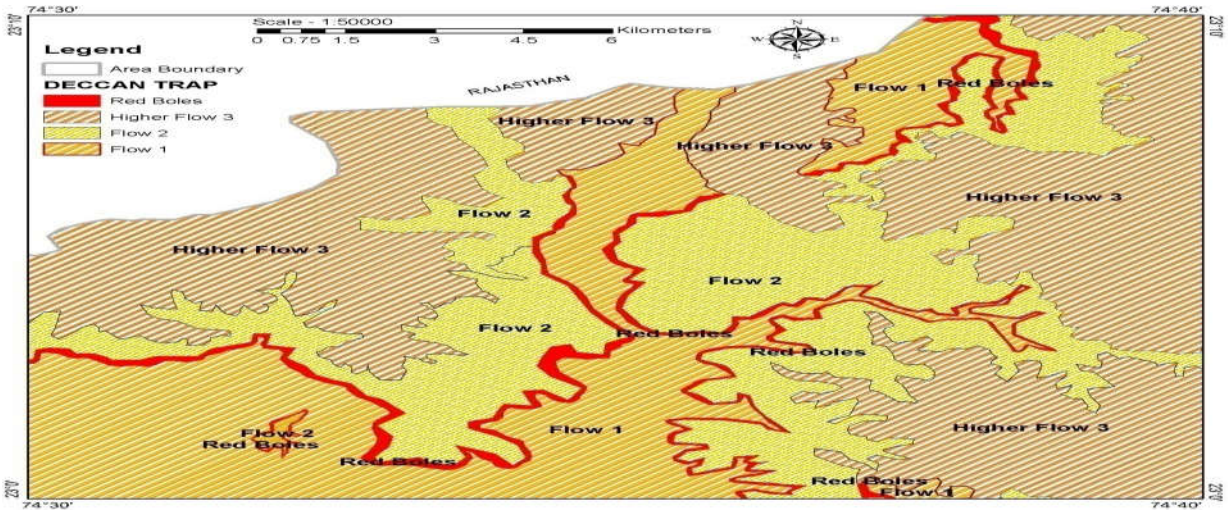

Figure 2: Geological Map of Thandla area, Jhabua district, Madhya Pradesh.

2. HYDROGEOLOGICAL SURVEY OF STUDY AREA

Systematic hydrogeological survey is the first step in hydrogeological analysis of basin / area. Survey is conducted to determine the nature of ground water conditions of present study area. Procedure for systematic hydrogeological survey is first carried out by reconnaissance survey, with the help of Toposheet along with detailed well inventory in respect of existing different wells in area of investigation. Study area covers 366.58 sq. km in vicinity of Thandla town in Jhabua district (Toposheet Number 46 I/12). Well inventory includes the collection of data such as locations, name of owner, diameter, total depth of well, static water level, purpose and yield of water in the wells.

The measurement of hydrogeological data in respect of 197 open dug wells have been recorded (Figure 3). Out of 197 dug wells, 35 open dug wells have been selected for detailed analysis, in order to visualize the characteristic of shallow ground water system in Thandla area (Figure 4).

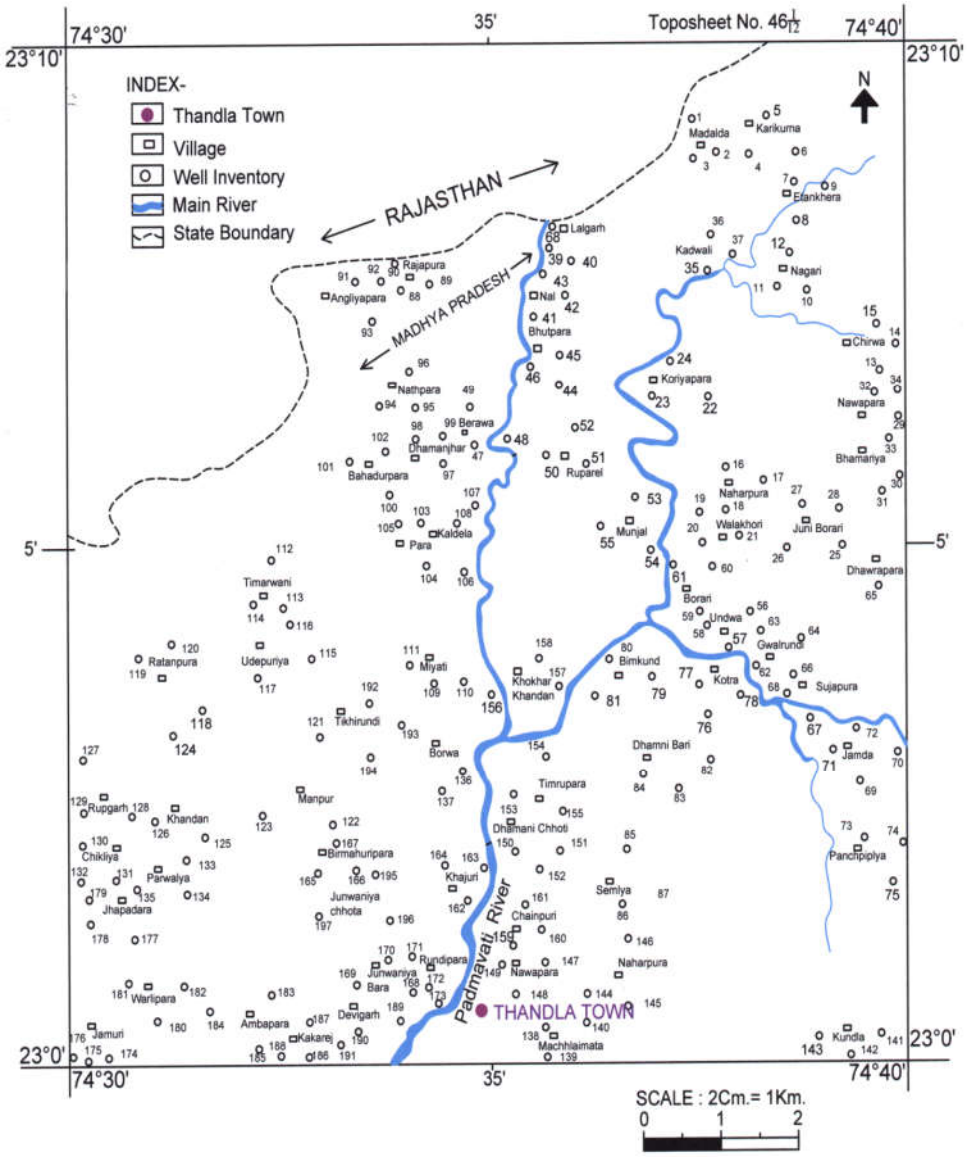

Figure 3: Location Map of open dug wells in the Thandla study area, Jhabua district, Madhya Pradesh.

Monitoring of seasonal ground water levels has been conducted with a view to study the variations in ground water levels during post- and pre-monsoon periods.

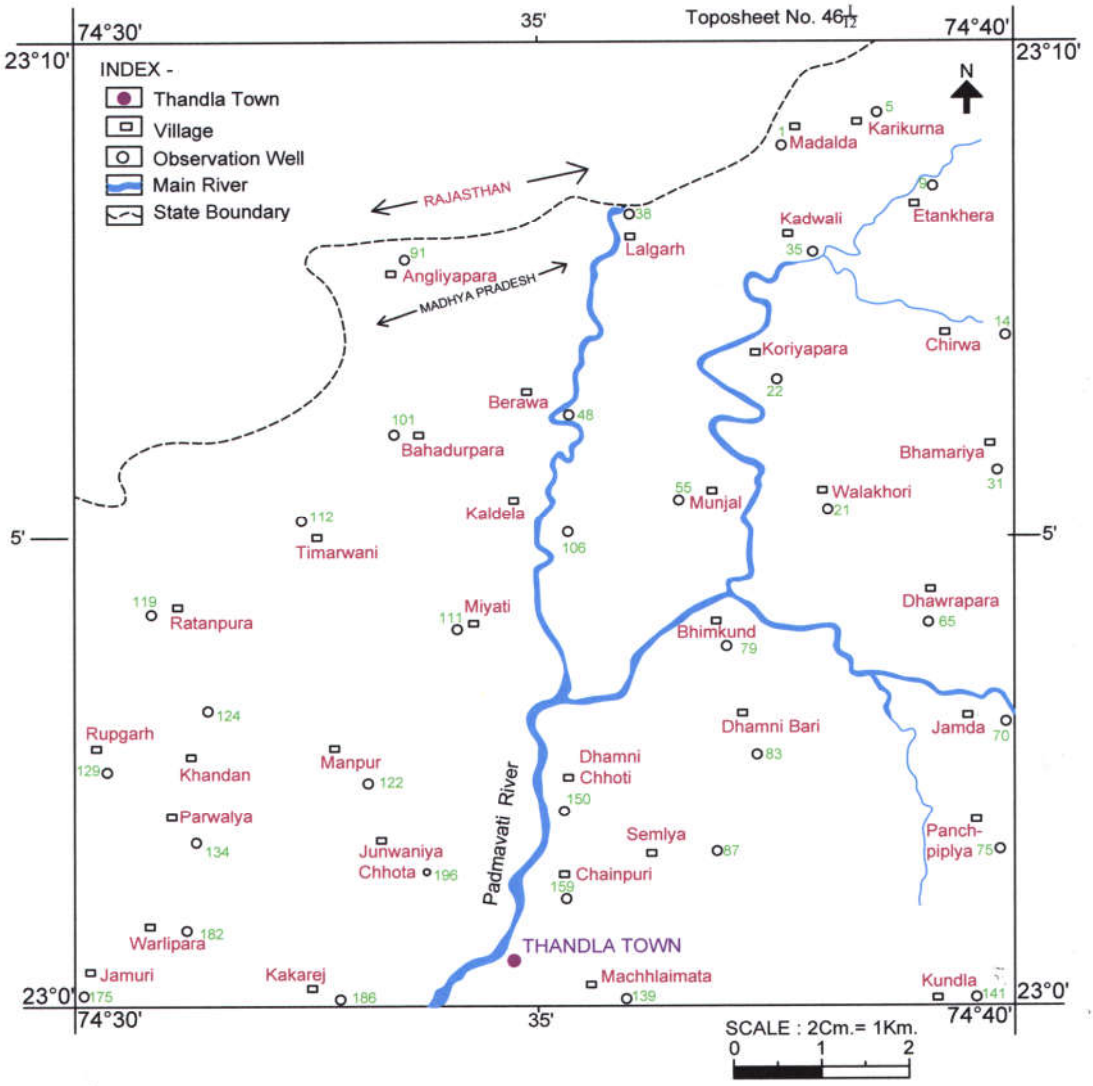

Figure 4: Location Map of Observation wells of Thandla area, Jhabua region, M.P.

The well inventory data include, the well diameter, total depth of well, static water level, fluctuation, location of well, name of owner and purpose are recorded. The water level measurement in these well, were taken up during post-monsoon and pre-monsoon period to observe the variation in water level and study of movement of ground water by preparing water level contour map of different post-monsoon and pre-monsoon seasons. The present work has been limited to nature of shallow ground water régime, as bore holes data not available for analysis.

3. DUG WELL DATA ANALYSIS

35 observation wells have been monitored during post-monsoon and pre-monsoon seasons to analyze the dug wells data (Table 1).

Table 1: Data analysis of dug wells in the Thandla study area, Jhabua district, Madhya Pradesh

S. No.	Well No.	Location	Name of Owner	G. L. (m.) A.M. S.L.	Dia. (m)	Total Depth (m.) B.G.L.	Static water level (m)		Reduced water level (m)		Fluctuation (m.)	Lined /Unlined	Mode of Lifting	Use of Well
							Post-monsoon	Pre-monsoon	Post-monsoon	Pre-monsoon				
1	1	*Madalda*	Bhunda Bhuriya	411	9.10	5.50	1.80	4.50	409.2	406.5	2.7	Lined Well	Manual, Pump	A+ D
2	5	*Karikurna*	Nathu Charpota	420	7.45	5.10	1.70	3.05	418.3	416.95	1.35	Lined Well	Manual, Pump	A+ D
3	9	*Etankhera*	Ramesh Bhuriya	409	7.60	7.20	2.30	5.80	406.7	403.2	3.5	Unlined Well	Manual	A
4	14	*Chirwa*	Devchand Katara	420	10.00	5.10	2.30	4.00	417.7	416.0	1.7	Unlined Well	Manual, Pump	A
5	21	*Walakhori*	Mansingh Maida	360	8.10	10.20	2.00	9.05	358.0	350.95	7.05	Lined Well	Manual, Pump	A+ D
6	22	*Koriyapara*	Havasingh Damor	360	8.00	6.15	1.90	5.00	358.1	355.0	3.1	Lined Well	Manual, Pump	A+ D
7	31	*Bhamariya*	Karama Singad	380	8.40	8.00	2.70	4.07	377.3	375.93	1.37	Unlined Well	Manual, Pump	A+ D
8	35	*Kadwali*	Ramaji Bhuriya	402	7.50	6.07	2.00	4.00	400.0	398.0	2.0	Lined Well	Manual, Pump	A+ D
9	38	*Lalgarh*	Punna Damor	400	10.05	7.09	1.90	5.02	398.1	394.98	3.12	Lined Well	Manual, Pulley, Pump	A+ D
10	48	*Berawa*	Galiya Maida	350	7.47	10.06	2.70	9.40	347.3	340.6	6.7	Lined Well	Manual, Pump	A+ D
11	55.	*Munjal*	Matiyas Damor	340	6.00	10.50	2.00	8.48	338.0	331.52	6.48	Lined Well	Manual, Pump	A+ D
12	65	*Dhawrapara*	Nathu Machhar	358	6.50	8.00	2.10	7.48	355.9	350.52	5.38	Lined Well	Manual, Pulley, Pump	A
13	70	*Jamda*	Kasara Damor	340	8.51	7.62	1.90	3.55	338.1	336.45	1.65	Unlined Well	Manual, Pump	A+ D
14	75	*Panchpiplya*	Dhanaji Dodiyar	364	6.50	10.00	2.10	8.05	361.9	355.95	5.95	Lined Well	Manual, Pulley, Pump	A+ D
15	79	*Bhimkund*	Manak Katara	329	5.55	14.08	2.50	9.12	326.5	319.88	6.62	Lined Well	Manual, Pulley, Pump	A+ D
16	83	*Dhamni Bari*	Prakash Katara	360	10.45	9.50	2.10	8.49	357.9	351.51	6.39	Unlined Well	Manual, Pump	A+ D
17	87	*Semlya*	Dita Katija	337	8.05	9.02	2.00	6.05	335.0	330.95	4.05	Unlined Well	Manual, Pump	A+ D

18	91	*Angliyapara*	Mangilal Garwal	400	7.02	8.00	2.10	7.45	397.9	392.55	5.35	Unlined Well	Manual, Pump	A+ D
19	101	*Bahadurpara*	Kalla Bhuriya	400	7.00	8.13	2.50	5.53	397.5	394.47	3.03	Lined Well	Pump	A
20	106	*Kaldela*	Mangliya Kharadi	338	8.22	10.04	2.70	9.00	335.3	329.0	6.3	Lined Well	Manual, Pump	A+ D
21	111	*Miyati*	Kusal Khihori	328	7.00	9.27	2.20	8.40	325.8	319.6	6.2	Lined Well	Pulley, Pump	A+ D
22	112	*Timarwani*	Mansingh Amaliyar	360	11.54	7.50	1.90	3.50	358.1	356.5	1.6	Unlined Well	Manual, Pump	A+ D
23	119	*Ratanpura*	Divan Damor	344	7.81	7.00	1.80	5.00	342.2	339.0	3.2	Unlined Well	Manual, Pump	A+ D
24	122	*Manpur*	Jogee Damor	322	10.36	12.26	2.50	8.50	319.5	313.5	6.0	Lined Well	Pump	A
25	124	*Khandan*	Versingh Muniya	317	10.50	16.00	3.00	14.00	314.0	303.0	11.0	Lined Well	Manual, Pump	A+ D
26	129	*Rupgarh*	Densingh Bhuriya	311	8.52	9.87	2.10	6.70	308.9	304.3	4.6	Unlined Well	Manual, Pump	A+ D
27	134	*Parwalya*	Kanta Muniya	298	7.22	9.27	2.10	7.50	295.9	290.5	5.4	Lined Well	Manual, Pump	A+ D
28	139	*Machhlaimata*	Kasan Bhabhor	308	9.02	12.06	2.00	9.00	306.0	299.0	7.0	Lined Well	Manual, Pump	A
29	141	*Kundla*	Joga Khadiya	346	8.02	9.22	2.00	8.04	344.0	337.96	6.04	Unlined Well	Manual, Pump	A+ D
30	150	*Dhamni Chhoti*	Joraji Bhabhor	325	7.04	11.00	2.10	9.05	322.9	315.95	6.95	Lined Well	Manual, Pump	A+ D
31	159	*Chainpuri*	Goverment	311	8.90	9.18	2.30	8.07	308.7	302.93	5.77	Lined Well	Manual, Pulley, Pump	A
32	175	*Jamuri*	Jamura Maida	300	8.02	11.34	2.70	4.00	297.3	296.0	1.3	Lined Well	Manual, Pulley, Pump	A+ D
33	182	*Warlipara*	Tansingh Bhuriya	287	6.20	8.26	2.60	6.00	284.4	281.0	3.4	Unlined Well	Manual, Pump	A
34	186	*Kakarej*	Khanu Gamod	297	8.06	9.25	2.00	8.06	295.0	288.94	6.06	Lined Well	Manual, Pulley, Pump	A+ D
35	196	*Junwaniya Chhota*	Khusal Muniya	320	8.50	6.59	2.10	4.50	317.9	315.5	2.4	Unlined Well	Manual, Pump	A+ D

Abbreviations G.L. = Ground Level, A.M.S.L. = Above Mean Sea Level, Dia. **=** Diameter, B. G.L. = Below Ground Level, A = Agriculture, D = Domestic **/** Drinking.

(a) Diameter of Wells

The analysis of diameter of well measurements indicate that 35 dug wells have a range from 5.55 to 11.54 m. (Table 2). Only 1 well is having a smallest diameter range of 5 to 6 m at village of *Bhimkund* and large diameter range of 11 to 12 m is also represented by 1 well at village of *Timarwani*. The majority of 12 wells are within the range of 8 to 9 m indicating withdrawal of adequate water from the open dug wells existing in the Thandla study area.

Table 2: Diameter range of dug wells in Thandla area, Jhabua district, M. P.

S. No.	Range of diameter (m.)	Number of wells	Percentage (%)
1	5-6	1	2.85
2	6-7	4	11.42
3	7-8	10	28.57
4	8-9	12	34.28
5	9-10	2	5.71
6	10-11	5	14.28
7	11-12	1	2.85
	Total	**35**	**99.96 %**

(b) Total Depth of Well

The analysis of total depth of well measurements indicates that 35 dug wells have a range from 5.10 to 16.00 m.b.g.l. (Table 3). Only 3 wells have a small depth range of 5 to 6 m.b.g.l. at *Karikurna,* and large depth range of 16 to 17 m.b.g.l. is also represented by 1 well at *Khandan.* The majority of 8 wells are within the range of 9 to 10 m.b.g.l. indicating withdrawal of adequate water from the dug wells in the Thandla study area.

Table 3: Total depth range of dug wells in Thandla area, Jhabua district, M.P.

S. No.	Range of total depth (m.) b. g. l.	Number of wells	Percentage (%)
1	5-6	3	8.57
2	6-7	3	8.57
3	7-8	5	14.28
4	8-9	5	14.28
5	9-10	8	22.85
6	10-11	5	14.28
7	11-12	2	5.71
8	12-13	2	5.71
9	13-14	-	-
10	14-15	1	2.85
11	15-16	-	-
12	16-17	1	2.85
	Total	**35**	**99.95 %**

(c) Static Water Level

The static water levels have been measured in 35 observation open dug wells, in the study area during post-monsoon and pre-monsoon (Table 4). The static water level during post-monsoon varies from 1 to 2

m.b.g.l., in only 7 wells are observed. Only 1 well at *Khandan* within the range of 14 to 15 m.b.g.l. has been recorded.

Table 4: Seasonal Static water level in wells of study area, Jhabua district, M.P.

S. No.	Range of static water level (m.) b.g.l.	Post-monsoon		Pre-monsoon	
		Number of wells	Percentage (%)	Number of wells	Percentage (%)
1	1-2	7	20	-	-
2	2-3	27	77.14	-	-
3	3-4	1	2.85	3	8.57
4	4-5	-	-	6	17.14
5	5-6	-	-	5	14.28
6	6-7	-	-	3	8.57
7	7-8	-	-	3	8.57
8	8-9	-	-	8	22.85
9	9-10	-	-	6	17.14
10	10-11	-	-	-	-
11	11-12	-	-	-	-
12	12-13	-	-	-	-
13	13-14	-	-	-	-
14	14-15	-	-	1	2.85
Total		**35**	**99.99 %**	**35**	**99.97 %**

(d) Water Level Fluctuation

The fluctuation of ground water level of the study area calculated on the basis of data collected from the open dug wells during the period of post-monsoon and pre-monsoon. The maximum numbers of 10 wells reveal fluctuation of water level within the range of 6 to 7 m.b.g.l. The minimum fluctuation has been observed within range of 1 to 2 m.b.g.l. at villages of *Karikurna, Chirwa, Bhamariya, Jamda, Timarwani and Jamuri*. The highest fluctuation range of 11 to 12 m.b.g.l. has been noted in 1 well at *Khandan* village. The range of variation in ground water level has been recorded (Table 5). The seasonal fluctuation analysis of ground water levels within range of 1 to 2 m.b.g.l. indicates ground water potential sites in the vicinity of *Karikurna, Chirwa, Bhamariya, Jamda, Timarwani and Jamuri*.

Table 5: Fluctuation range of water level of study area, Jhabua district, M.P.

S. No.	Fluctuation range (m.)	Number of wells	Percentage (%)
1	1-2	6	17.14
2	2-3	3	8.57
3	3-4	6	17.14
4	4-5	2	5.71
5	5-6	5	14.28
6	6-7	10	28.57
7	7-8	2	5.71
8	8-9	-	-
9	9-10	-	-
10	10-11	-	-
11	11-12	1	2.85
	Total	**35**	**99.97%**

Analysis of Ground Water Level Contour Maps

The ground water level contour maps of Thandla area during post-monsoon and pre-monsoon periods have been constructed (Figure 5 and Figure 6) and described in the following text:

(a) Post-monsoon Ground Water Level Contour Map

Post-monsoon ground water level contour map has been prepared on 2 cm = 1 km scale. The ground water level contour map of the study area has been prepared on the basis of the reduced water level (Bench mark – Static water level). Ground water level contour map has been constructed by plotting reduced water level contours on the base map of study area. The area is mainly drained by Padmavati River, different direction of water flow is towards Padmavati River. Ground water flow direction has been marked, with the help of a symbol 'arrow', on the ground water level contour map (Figure 5). Several villages located at *Madalda, Karikurna, Etankhera, Munjal, Walakhori, Panchpiplya, Kundla, Dhamni Chhoti, Chainpuri, Semlya, Machhlaimata, Kakarej, Junwaniya Chhota, Warlipara, Parwalya, Khandan, Manpur, Rupgarh, Miyati, Ratanpura and Timarwani* indicate widely spaced ground water level contours pointing out the favourable zone of ground water recharge. The water in dug wells yield rather inadequate quantity of water in several wells located at villages of *Bahadurpara, Angliyapara, Berawa, Lalgarh, Kadwali, Koriyapara, and Chirwa.*

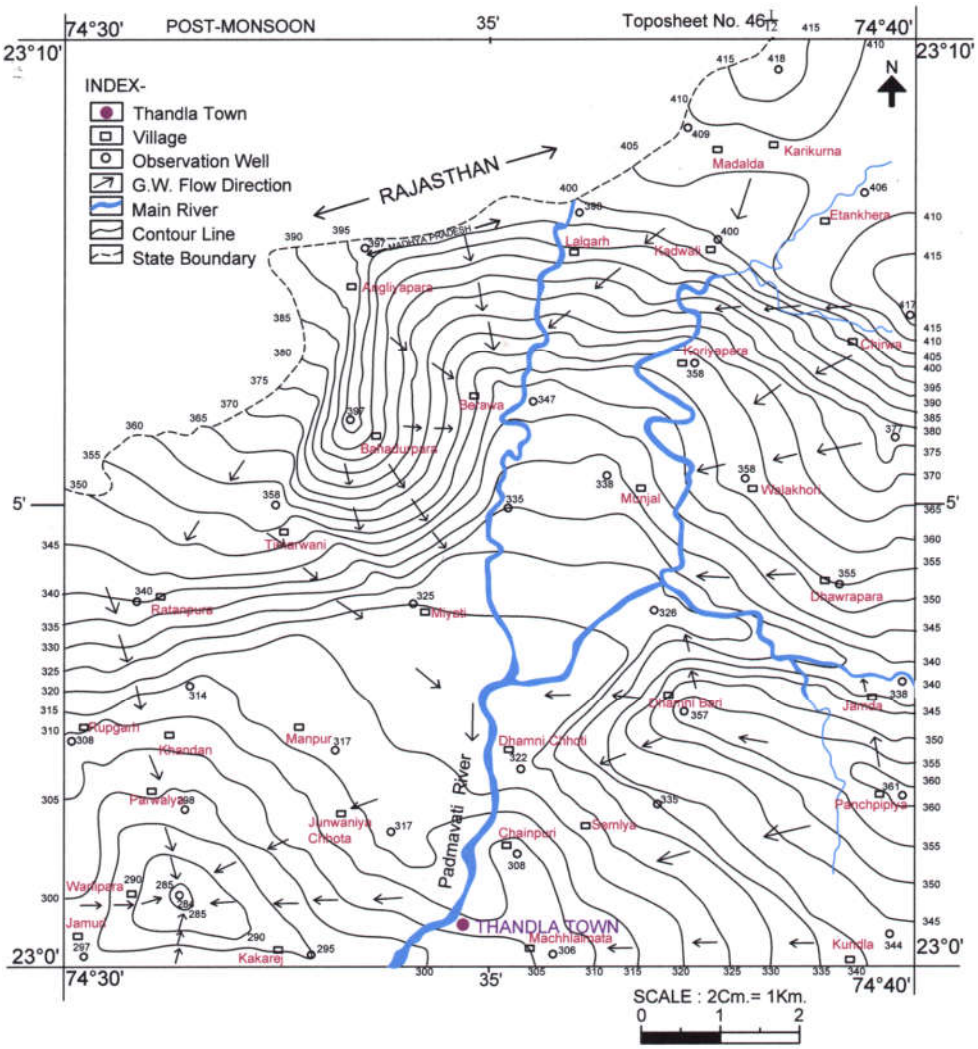

Figure 5: Post-monsoon ground water level contour map of Thandla study area.

(b) Pre-monsoon Ground Water Level Contour Map

Pre-monsoon contour levels are more or less similar to pattern, except at places namely *Karikurna, Miyati, Junwaniya Chhota and Panchpiplya*. In general, most of the wells indicate lowering of water levels during pre-monsoon period (Figure 6) as compared to post-monsoon period (Figure 6). The ground water levels in the area reveal fluctuation range from 1.3 *(Jamuri)* to 11.0 *(Khandan)* m.b.g.l. In the study area most of the wells located at *Manpur, Khandan, Rupgarh, Prwalya, Warlipara, Jamuri, Kakarej, Miyati, Munjal, Panchpiplya, Dhamni Chhoti, Chainpuri, Machhlaimata, Kundla, Madalda, Karikurna, and Etankhera* indicate fairly good yield of water in dug wells during even Pre-monsoon period. A few number of wells become almost dry during Pre-monsoon period at villages of *Angliyapara, Bahadurpara, Kaldela, Lalgarh, Berawa, Koriyapara and Dhawrapara.*

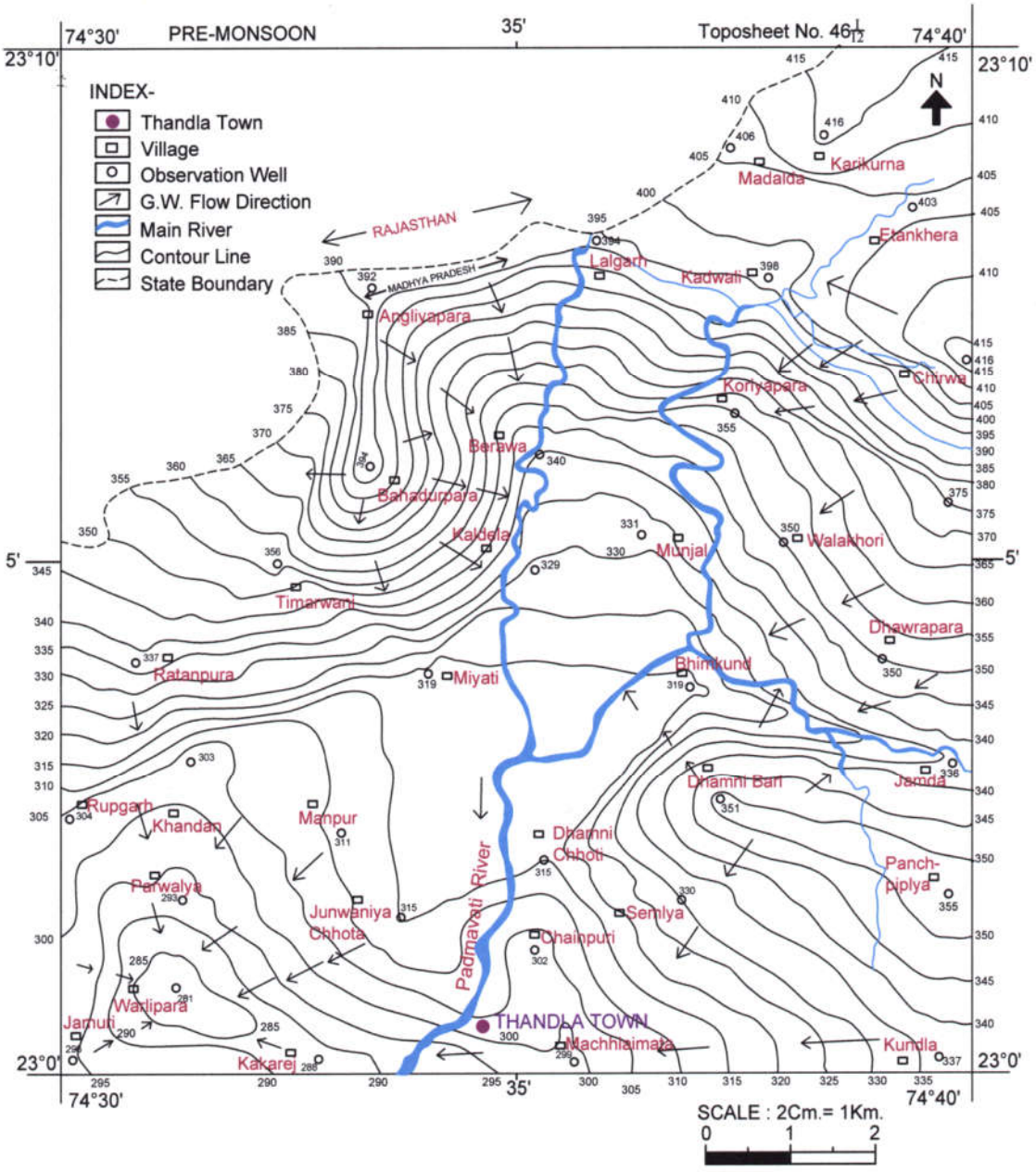

Figure 6: Pre-monsoon ground water level contour map of Thandla study area.

Monitoring of Seasonal Ground Water Levels

The monitoring of ground water levels in observation wells have been conducted during Post-monsoon and Pre-monsoon periods in Thandla study area. It has been observed that the water levels indicate a range from 1.3 to 11.0 m.b.g.l. during the period from Post-monsoon to Pre-monsoon. The minimum fluctuation range of 1 to 2 m. is indicating good yield of water in wells in vicinity of Karikurna, *Chirwa, Bhamariya, Jamda, Timarwani and Jamuri.* The maximum seasonal fluctuation of 11.0 m.b.g.l. has been recorded at *Khandan* is indicating the shortage of water supply and exhibits rather unsuitable prospects for construction of new dug wells in the study area. It is recommended that the dug wells in the study area may be further constructed up to a range of 07 m fluctuation of water in dug wells (Figure 7).

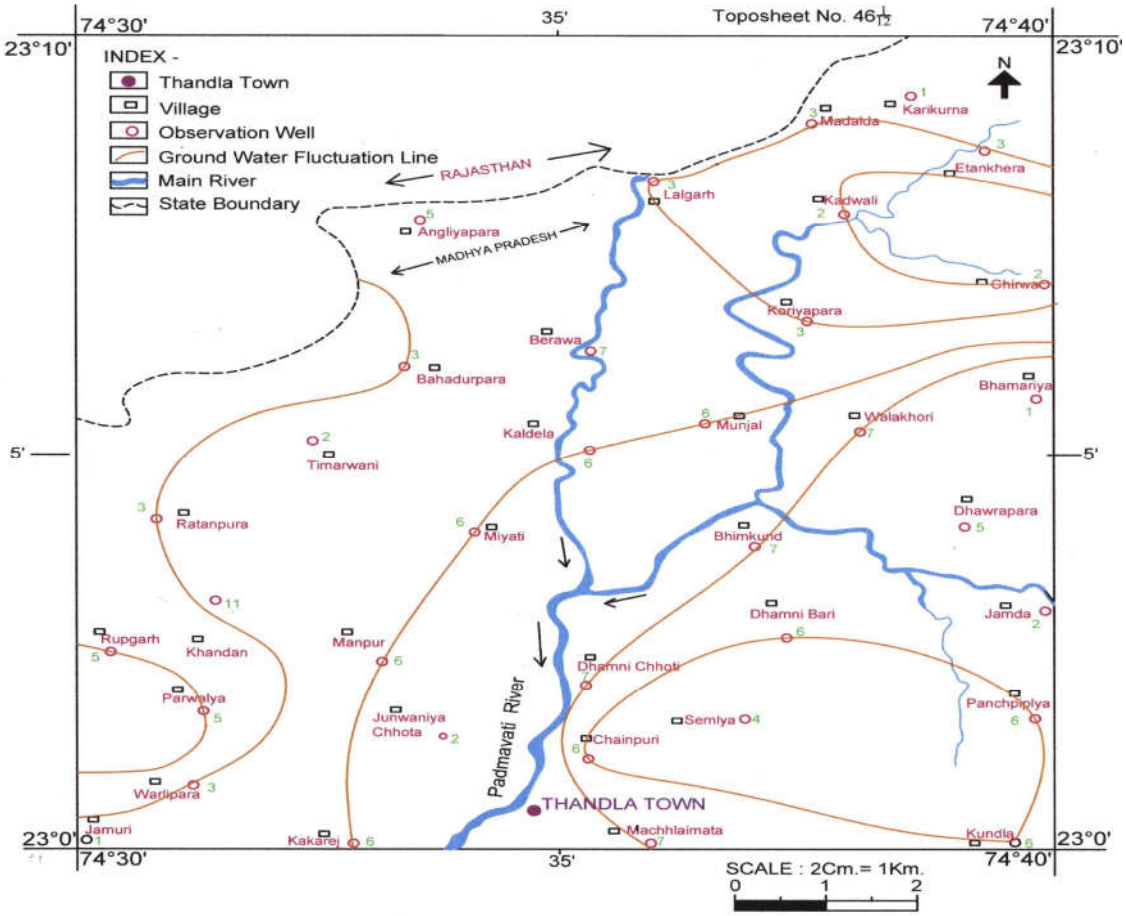

Figure 7: Fluctuation Map of Thandla area, Jhabua district, Madhya Pradesh.

4. GROUND WATER MOVEMENT

The ground water movement is through pore spaces or interstices of weathered, vesicular zones, fractured and jointed zone of basaltic lava flows mostly as laminar flow. Authors have selected 35 open dug wells observed during post-monsoon and pre-monsoon period to observe trend of ground water flow based on the ground water level contour map (Figure 5 and Figure 6) prepared for monsoon period. Ground water moves from levels of higher energy to lower energy, where by its energy is essentially the result of elevation and pressure. The direction of ground water flow has been exhibited by the symbol "arrow" on the ground water level contour maps. In general, the ground water movement in study area is towards the Padmavati River. The direction of ground water movements are determined by drawing perpendicular lines from higher ground water contour levels to lower ground water contour levels, which point out effluent nature of Padmavati River, i.e. ground water movement is towards the Padmavati River.

5. CONCLUSION

The paper has provided results of analysis of open dug wells of Thandla study area. Hydrogeological data in respect of 35 open dug wells have been monitored and analyzed. The well data exhibits a fairly wide range of shallow ground water system of Thandla area confined to Jhabua district, Madhya Pradesh. The hydrogeological data analysis reflects the characteristics of the ground water system. It has been observed that implementation of a ground water development and management plan in the Thandla area to resolve the problem of sustained ground water supply to the inhabitants.

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