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VARIATION ANALYSIS OF GROUND WATER LEVELS IN BARWANI ENVIRONS, BARWANI DISTRICT, MADHYA PRADESH, INDIA

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ABSTRACT

The paper presents an account of seasonal variation analysis of ground water levels measured in the dug wells of Barwani study area confined to the Barwani district, Madhya Pradesh, India. Barwani area is occupied by basaltic lava flows of the Deccan Trap Volcanic Province of Upper Cretaceous to Eocene period. The measurements of static water levels in respect of 60 dug wells during post-monsoon and pre-monsoon periods have been recorded and displayed. Post- monsoon static water levels range from 1 m. b.g.l. (Pichori and Borlai) to 11 m b.g.l. (Sisgone) whereas, the Pre - monsoon static water levels range from 5 m.b.g.l. (Bajrikheda Govt.) to 17 m.b.g.l.(Barwani). The fluctuation range of 2 m (Sajwani, Talun, Talun Govt., Piplaj and Bajrikheda) to 10 m (Barwani, Sajwani, Sajwani and Lonsara) has been recognized during the post- and pre-monsoon periods. The variation of ground water levels can be assigned to the topography, geology, over –exploitation and amount of rainfall recharge. The ground water level contour maps constructed for Post- and Pre-monsoon periods help in demarcation of favorable ground water potential zones in vicinities of Rajghat, Chikalda, Gangle, Dehdola, Bhilkheda, Kasrawad, Balkar, Bomia, Boribdhan and Lonsara villages of the Barwani study area.

Keywords: Analysis, Variation, Ground water levels, rainfall recharge, Barwani, Madhya Pradesh, India

1. INTRODUCTION

The term 'Hydrogeology' has been derived from combination of Greek words (*hydro* = water + *geology* = study of the Earth), i.e .science of water geology. Hydrogeology is the general term for the water of

the earth, which deals with the distribution and movement of ground water in the soil and rocks of the Earth's crust. It has been described by Meinzer (1923) that the "Hydrology is the science that relates to the water of the earth. The water of the earth can be divided into three parts that which occurs in the atmosphere, that which rests on the surface of the solid part of the earth, and that which occurs below the surface. The water below the surface can be divided (with some exceptions) into two parts that which occurs in the interstices of the rocks and that which is supposed to occur in the earth's interior, where interstices can not exist because of the weight of the overlying rocks and where the water, if any exists there, must be in a sort of rock solution". Tolman (1937) has defined hydrogeology as "all the sciences geology is of greatest importance than the study of subsurface water". Todd (1959, 1980, and 2010) described the hydrogeology as "the science of the occurrence, distribution and movement of water below the surface of the earth". Geohydrology has an identical connotation, and hydrogeology differs only by its greater emphasis on the geology.

The discipline of Hydrology has been described by Raghunath (1982) as "the science which deals with the occurrence, distribution and disposal of water on the planet; it is the science which deals with the various phases of the hydrologic cycle". Nagabhushaniah (2001) considered Hydrology as "the applied science concerned with the water of hydrosphere in all its states such as occurrence, distribution and circulation through the unending hydrologic cycle of precipitation, consequent runoff, stream flow, infiltration and storage, eventful evaporation and reprecipitation. Hydrology is dependent on other allied sciences such as Meteorology and climatology, physical geography, Agronomy and Forestry, geology and soil science, geomorphology and hydraulics". Karanth (2003) described that the "water existing in the liquid, solid or gaseous state in the rocks of the earth is called subsurface water. Subsurface water can be divided into ground water or phreatic water, vadose water and internal water". Thokal, *et al*. (2004) considered Hydrogeology as "the study of the interaction of groundwater and the surrounding soil and rock. Geohydrological investigation of groundwater resources regarding their occurrence, movement, storage, discharge, quality and their appraisal to determine the quantity they can yield". Ground water occurs in large quantities in Valleys as compared to Hill regions. The water bearing formations are known as 'Aquifers' on the basis of the water holding and transmitting characteristics, aquifers are further classified as Aquiclude, Aquifuge, and Aquitard. The vesicular and fractured Basalts are the main aquifers in the Barwani study area.

2. CHARACTERISTICS OF STUDY AREA

The study area is located in Barwani District, Madhya Pradesh, India within Latitude 22° 0' to 22° 6' N and Longitude 74° 50' to 75° 0'E (Survey of India Toposheet No. 46 J/16; Figure 1). Barwani area is mainly drained by the Narmada River and its tributaries. Barwani is famous for Bawangaja (a holy place of Jain religion). The climate of Barwani area is pleasant and healthy. The township of Barwani study area is characterized by a fairly good environmental scenario in vicinity of the Deccan Trap Volcanic Provenance. The present study area constitutes a part of Barwani district covering an area of 184.45 sq km in the south-western part of Madhya Pradesh. Barwani is surrounded by the great Satpura hills This area becomes one of the most beautiful places in central India, during rainy season and usually known as the Paris of Nimar. Barwani District is bordered by the districts of Dhar, Khargone (Madhya Pradesh} and Nadurbar (Maharashtra) The nearest railway station is Mhow (Indore) and also approachable by road.

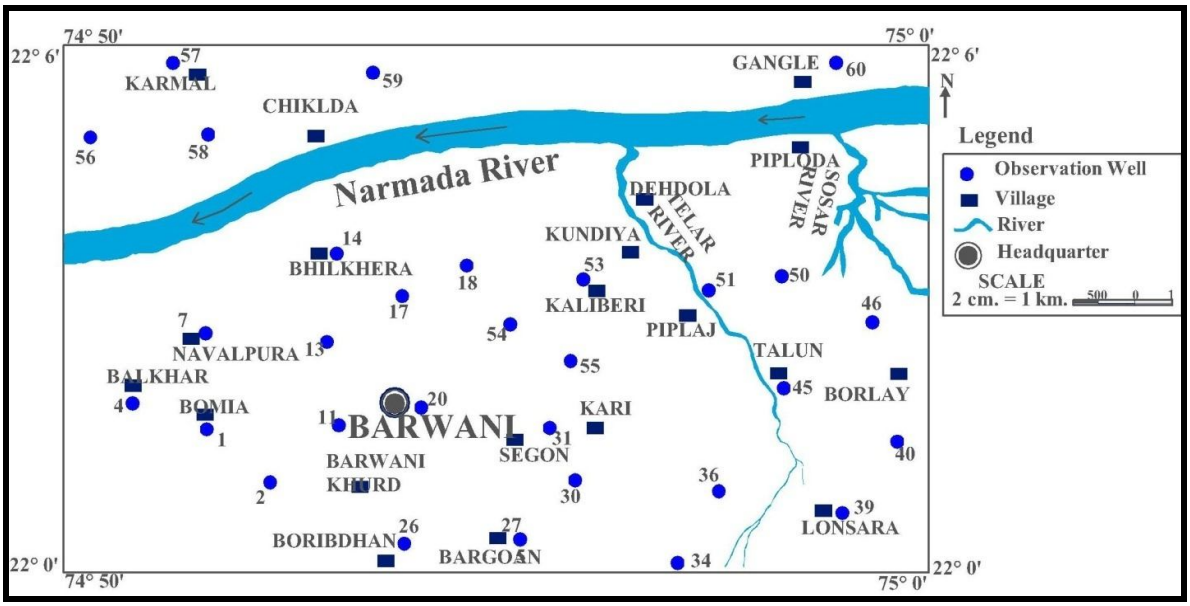

Fig. 1: Location map of examined (30) open dug wells in Barwani study area, Madhya Pradesh

Barwani study area is located in vicinity of the Khargone region of Madhya Pradesh, which is manly dominated by the Deccan traps. The traps are composed of different types of lava flows extending in the states of Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, and Karnataka, covering an area more than 5, 10,000 sq km. Narmada River flows through a lineament, namely "Son - Narmada Lineament. The presence of lineaments and dykes is comparatively less in study area. Barwani fault extends on either side of the Narmada River. Two types of basaltic flows separated by red bole are observed. Soil is of two types i.e. Black cotton and alluvial. The Deccan traps have been divided in to three groups as Upper, Middle and Lower on the basis of stratigraphy and presence of Intra-trappean beds. Blandford (1869), Pascoe (1964), Krishnan (1968, 1982) and a majority of workers have followed the classification of Deccan traps into three divisions as Lower, Middle and Upper (Table 1).

Table 1: Classification of the Deccan traps (After Krishnan, 1968, 1982)

Divisions	Distribution	Characters
Upper traps (450 m)	Bombay and Kathiawar	With numerous inter- trapean beds and layers of volcanic ash.
Middle traps (1200 m)	Central India and Malwa	With numerous ash- beds in the upper portion and practically devoid of inter-trapeans
Lower traps (150 m)	Central provinces And Eastern areas	With inter-trapean beds but rare ash -beds

3. HYDROGEOLOGICAL ANALYSIS

Hydrogeological examination of the study area covering 184.45 sq. km, involves collection of relevant data in respect of 60 open dug wells existing in the Barwani Study Area. The data collection includes the location of wells, measurements of diameter, total depth and static water level of wells and mode of lifting water from the wells (Table 2).The ground water occurs both under confined and unconfined aquifers. The water yielding zones are the fractured, weathered and jointed zones. The ground water probability is more in the basalts having numerous void spaces.

Table 2: Details of existing dug well data measured in Barwani study area, Madhya Pradesh, India

S. No.	Name of the Village	Owner's name of the well	Diameter of well (in m)	Total depth of wells (m. b.g.l.)	Static Water Levels (m. b.g.l.)		Fluctuation (m)	Mode of lifting the water	Nature of wells Line/ Unlined	Uses D/ I
					Post-Monsoon	Pre–Monsoon				
1	Bomiya	Gyansingh	7	18	5	14	9	M / 3	Unlined	I
2	Bomiya	Gangaram	8	15	7	12	5	M / 3	Unlined	I
3	Bomiya	Dheyan	7	12	2	10	8	M / 3	Unlined	I
4	Balkhar	Ramesh	6	9	1	6	5	M / 3	Unlined	I
5	Pichori	Kellash	6	8	1	7	6	M / 5	Lined	D / I
6	Pichori	Niharsingh	8	13	3	12	9	M / 5	Unlined	D / I
7	Katra	Amarsingh	6	11	3	9	6	M / 3	Lined	D / I
8	Klyanpura	Rajaram	9	15	8	11	3	M / 5	Unlined	D / I
9	Klyanpura	Kellash	6	13	5	10	5	M / 5	Lined	D / I
10	Klyanpura	Ramesh	8	12	6	10	4	M / 5	Lined	D / I
11	Barwani k.	Deva	8	12	3	9	6	M / 5	Unlined	I
12	Barwani	Bhagwan	7	18	5	15	10	M / 5	Unlined	D / I
13	Klyanpura	Kamal	6	13	5	10	5	M / 5	Lined	D / I
14	Bhilkheda	Govt.	7	18	9	12	3	Bucket	Lined	D
15	Barwani	Gangaram	7	18	8	15	7	M / 5	Lined	D / I
16	Rajghat	Gopal	3	14	4	10	6	M / 5	Lined	I
17	Barwani	Patidar	7	19	8	12	4	M / 5	Lined	I
18	Barwani	Kelash	6	18	7	14	7	M / 3	Lined	I

	Name of the Village	Owner's name of the well	Diameter of well (in m)	Total depth of wells (m. b.g.l.)	Static Water Levels (m. b.g.l.)		Fluctuation (m)	Mode of lifting the water	Nature of wells Line/ Unlined	Uses D/ I
					Post-Monsoon	Pre–Monsoon				
19	Ranjitchok	Govt.	3	8	2	6	4	Bucket pulley	Lined	D
20	Panwadi	Govt.	3	7	2	6	4	Bucket pulley	Lined	D
21	Barwani	Devisingh	4	13	6	10	4	M / 5	Lined	I
22	Gwalbeda	Gajanan	5	13	4	9	5	M / 3	Unlined	I
23	Amliyapani	Govt.	5	14	2	11	9	Bucket pulley	Lined	D
24	Barwani	Khandelwal	4	19	10	17	7	M / 5	Lined	D / I
25	Boribdhan	Nharsingh	5	13	5	10	5	M / 3	Lined	D / I
26	Boribdhan	Bhura	4	12	3	9	6	M / 3	Lined	D / I
27	Badgone	Santosh	4	8	2	7	5	M / 3	Unlined	I
28	Sajwani	Gopal	5	16	6	13	7	M / 5	Lined	D / I
29	Sajwani	Kamal	4	13	5	10	5	M / 5	Lined	D / I
30	Sajwani	Prakash	5	22	6	16	10	M / 5	Lined	I
31	Kari	Sengov	7	18	6	13	7	M / 3	Lined	D / I
32	Kari	Mahesh	7	13	8	11	3	M / 5	Lined	D / I
33	Sajwani	H.S.S.	4	7	5	7	2	Bucket pulley	Lined	D
34	Sajwani	Ramesh	4	17	4	14	10	M / 5	Lined	D / I
35	Sajwani	Sonu	5	16	6	11	5	M / 5	Lined	I
36	Lonsara	Jagdish	5	14	5	9	4	M / 5	Lined	D / I
37	Lonsara	Lokesh	6	13	5	8	3	M / 5	Lined	D / I
38	Lonsara	Raju	6	16	6	14	8	M / 5	Lined	I

40	Borlai	Kanaya	6	12	6	10	4	M / 5	Lined	D / I
41	Borlai	Lokesh	6	12	1	7	6	M / 5	Lined	I
42	Talun	Bajatta	7	12	5	7	2	M / 5	Lined	D / I
43	Borlai	Ramesh	5	19	6	12	6	M / 5	Lined	D / I
44	Borlai	Rakesh	9	13	7	10	3	M / 5	Lined	I
45	Talun	Govt.	3	11	4	6	2	M / 5	Lined	D
46	Borlai	Kelash	5	17	7	12	5	M / 5	Lined	D / I
47	Talun Buj.	Narendra	6	18	5	14	9	M / 5	Lined	D / I
48	Piplaj	Narayan	8	14	8	10	2	M / 5	Lined	D / I
49	Talun Kh.	Partap	6	17	6	11	5	M / 5	Lined	D / I
50	Talun Kh.	Badri	7	18	6	14	8	M / 5	Lined	D / I
51	Piplaj	Kamal	5	12	5	10	5	M / 5	Lined	I
52	Kundiya	Bhursingh	3	10	3	7	4	M / 5	Lined	D / I
53	Kaliberi	Mohan	5	18	7	14	7	M / 5	Unlined	D / I
54	Kaliberi	Jatan	9	12	3	12	9	M / 5	Unlined	D / I
55	Kari	Patidar	6	17	6	13	7	M / 5	Lined	D / I
56	Bajrikheda	Govt.	4	19	3	5	2	M / 3	Lined	D
57	Kadmal	Govt.	7	19	10	15	5	M / 3	Lined	D
58	Kaperkhe	Jadiya	6	9	4	8	4	M / 5	Lined	D / I
59	Sisgone	Govt.	4	18	11	14	3	M / 3	Lined	D
60	Gonglle	Govt.	5	17	9	12	3	Bucket pulley	Lined	D

Abbreviation: MBGL = Meter Below Ground Level, I = Irrigation, U = Unlined, D = Domestic.

The details of monitoring of hydrogeological data in the Observation wells are displayed (Table 3).

Table 3: Well inventory data and seasonal water level fluctuations in Barwani study area, M.P.

Well No.	Location of Dug wells	Owner name of wells	Ground level (m) AMSL	Static Water Level		Reduced Water Level		Fluctuation (m)
				Post Monsoon	Pre Monsoon	Post Monsoon	Pre Monsoon	
1	Bomiya	Gyansingh	178	5.00	14.00	173.00	164.00	9.00
2	Bomiya	Gangaram	200	7.00	12.00	193.00	188.00	5.00
3	Balkhar	Ramesh	168	1.00	6.00	167.00	162.00	5.00
4	Navalpura	Amarsingh	142	3.00	9.00	139.00	133.00	6.00
5	Barwani k.	Deva	176	3.00	9.00	173.00	167.00	6.00
-6	Klyanpura	Kamal	155	5.00	10.00	150.00	145.00	5.00
7	Bhilkheda	Govt.	140	9.00	12.00	131.00	128.00	3.00
8	Barwani	Patidar	150	8.00	12.00	142.00	138.00	4.00
9	Barwani	Kelash	142	7.00	14.00	135.00	128.00	7.00
10	Panwadi	Govt.	172	2.00	6.00	170.00	166.00	4.00
11	Boribdhan	Bhura	240	3.00	9.00	237.00	231.00	6.00
12	Badgone	Santosh	208	2.00	7.00	206.00	201.00	5.00
13	Sajwani	Prakash	193	6.00	16.00	187.00	177.00	10.00
14	Kari	Govt.	177	6.00	13.00	171.00	164.00	7.00
15	Sajwani	Ramesh	200	4.00	14.00	196.00	186.00	10.00
16	Lonsara	Jagdish	180	5.00	9.00	175.00	171.00	4.00
17	Lonsara	Kailash	180	2.00	12.00	178.00	168.00	10.00
18	Borlai	Kanaya	170	6.00	10.00	164.00	160.00	4.00
19	Talun	Govt.	162	4.00	6.00	158.00	156.00	2.00
20	Borlai	Kelash	148	7.00	12.00	141.00	136.00	4.00
21	Talun Kh.	Badri	153	6.00	14.00	147.00	139.00	8.00
22	Piplaj	Kamal	152	5.00	10.00	147.00	142.00	5.00
23	Kaliberi	Mohan	145	7.00	14.00	138.00	131.00	7.00
24	Kaliberi	Jatan	150	3.00	12.00	147.00	138.00	9.00
25	Kari	Patidar	162	6.00	13.00	156.00	149.00	7.00
26	Bajrikheda	Govt.	145	3.00	5.00	142.00	140.00	2.00
27	Kadmal	Kamal	142	10.00	15.00	132.00	127.00	5.00
28	Kaperkheda	Jadiya	145	4.00	8.00	141.00	137.00	4.00
29	Sisgone	Govt	144	11.00	14.00	133.00	130.00	3.00
30	Gonglle	Govt.	144	9.00	12.00	135.00	132.00	3.00

3.1 ANALYSIS OF WELL DATA

The water level measurements in 30 open dug wells have been recorded during the post-monsoon (October, 2013) and pre-monsoon (April, 2014) periods (Table 3) to observed the variation in water level and study of movement of ground water by preparing water level contour maps of post - and pre - monsoon seasons (Figure 2, 3). The analysis of dug wells data indicates that the diameter of wells in the Barwani study area ranges from 3 m. (Khalghat, Ranjitchok, Panwadi, Talun, and Kundiya) to 9 m. (Kalyanpura, Borlai and Kaliberi). The maximum number of wells is characterized by having a diameter range of 5-6 m constituting 23.33 % of total wells. The large diameter wells are 3 within range of 9 m constituting 5 % of the total examined wells. The depth range of dug wells from 7.0 m (Sajwani and Panwadi) to 22 m.b.g.l. (Sajwani). Depth of well within the range of 6-7 m.b.g.l. has been observed in 2 wells representing 3.33% of the total examined dug wells. The maximum range of depth within 21-22 m.bgl has been observed in 1 well constituting 1.66%. The maximum numbers of 10 wells each have been observed within the depth ranges of 12-13 m.b.g.l. and 17-18 m.b.g.l., which are representing 33.32% of total examined wells.

3.2 GROUND WATER LEVEL CONTOUR MAPS OF BARWANI

(1) Post-Monsoon Ground Water level contour map (October, 2013)

The ground water level contour map of the Barwani study area for the Post- Monsoon period (October, 2013) exhibits the pattern of ground water levels (Figure 2). It has been noted that the lowest water level elevation in the study area is 131 meters AMSL (Above mean sea level) is almost north part of the Barwani headquarter at village Bhilkheda. The highest water level elevation of 237 meters AMSL has been noted at Boribdhan village in the South corner of area

It has been noted that the ground water contours map exhibits rather widely spaced contoured almost throughout the study area, except in North and North East parts of the contour map in the study area of Bhilkhera, Dehdola, Rajghat, Kasrawad, Chikalda, Karmal and Kundiya villages. Moreover, the South direction of the ground water contour map at Bomiya, Balkhar, Bargone and Lonsara indicates widely spaced ground water level contours pointing out the favorable zones of ground water recharge. The directions of ground water movement are determined by drawing the perpendicular lines from higher level contours to lower level contours and marked by arrows on the map, which points out effluent nature of the rivers i.e. ground water movement is towards the Narmada River.

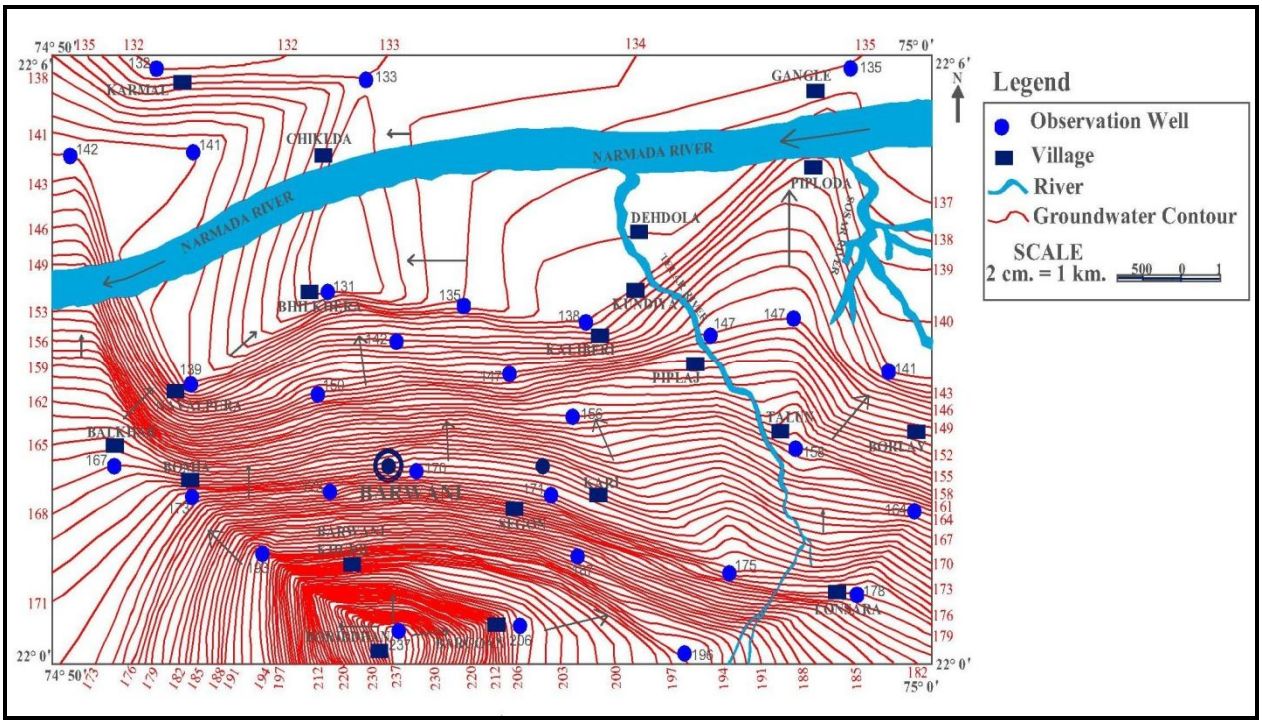

Fig. 2: Post-Monsoon (October, 2013) Water Level Contour Map of study area, Barwani district, Madhya Pradesh

(2) Pre-Monsoon Ground Water Level Contour Map (April, 2014)

The ground water level contour map prepared for Pre-monsoon period (April, 2014) displays that the lowest water level elevation of 127 meters AMSL exists at Kadmal village in North -West sector of Barwani study area (Figure 3). The highest water level elevation has been recorded at Boribdhan village as 231 meters AMSL in South. Particularly in North East part of contour in Rajghat, Chikalda, Gangle, Dehdola, Bhikheda, Kasrawad, Balkhar, Bomia, Boribdhan and Lonsara villages of contour map.

The ground water movement is more or less towards the Telar and Sosaur rivers revealing a little change in the ground water level contour map exhibiting the presence of Barwani Khurd, Barwani, Kari, Sengawa, Talun, Piplaj, Borlai, Sajwani, Kaliberi and Bomiya as compared to post- monsoon period. The comparative study of post and pre-monsoon ground water level contour maps (Figure 2 and 3) study reflects more or less identical nature of ground water levels is observed during both the reasons. The only difference is observed in the nature of ground water level contours. The ground water level contour maps constructed for Post and Pre-mansoon periods help in demarcation of favorable ground water potential zones in Barwani study area of Rajghat, Chikalda, Gangle, Dehdola, Bhilkheda, Kasrawad, Balkar, Bomia, Boribdhan and Lonsara Villages.

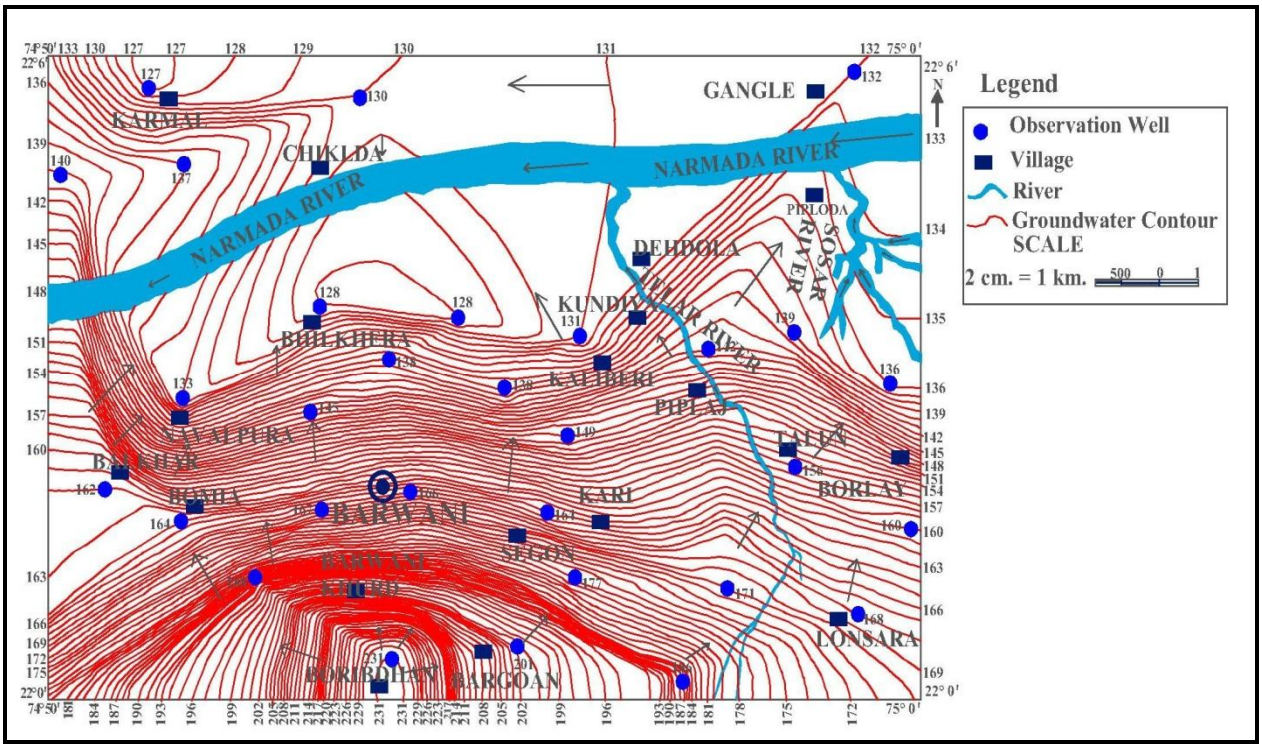

Fig. 3: Pre-Monsoon Water (April 2014) level contour map of study area, Barwani district Madhya Pradesh

3.3 GROUND WATER MOVEMENT

The movement of the ground water level has been determined on the basis of ground water contour map prepared for Post-monsoon (October, 2013) and Pre-monsoon (April, 2014) periods (Figure 2, 3). The directions of the ground water movement in the study area indicate seasonal variation in the nature of ground water contour and directions of ground water flow. In general, the ground water mainly moves towards the Narmada River. The Narmada River also contributes the water through openings in sediments and rocks occur in the zone of saturation, and are known as ground water flow. It has been observed that the ground water direction at few places, indicate convergence conditions namely at Bhilkhera, Dehdola, Rajghat, Kasrawad, Chikalda, Karmal and Kundiya. Whereas divergent conditions have been recorded near the village of Barwani Khurd, Barwani, Kari, Sengawa, Talun, Piplaj, Borlai, Sajwani, Kaliberi and Bomiya In general the direction of ground water flow in towards the Narmada River.

The nature of ground water flow is delineated in a particular area on the basis of construction of the ground water level contour maps (Fetter, 1990). The variation of ground water level in the Barwani study area has been determined on the basis of data collected from the open dug well during the period of Post-monsoon and Pre- monsoon. The monitoring of fluctuation in ground water levels from post monsoon to pre monsoon period has been determined on the basis of observation well data. The determinations of seasonal variations in groundwater levels are recorded (Table 3). The fluctuation pattern of static water levels in dug wells of the study area has been observed on the basis of measurements in respect of 30 observation dug wells (Table 3, Figure 4).

The variation is mainly caused by the difference in the amount of supply and withdrawal of ground water. The role of rain fall and topography of the area also affects the rise and fall of the water levels. The water table fluctuation into four basic types, was classified by Davis and DeWiest (1966), namely -
(i) Fluctuation owing to change in ground water storage.
(ii) Fluctuation brought about by atmospheric pressure in contact with the water surface in wells.
(iii) Fluctuation resulting due to deformation of aquifers and.
(iv) Fluctuation owing to disturbances within the well.

In the study area, the variation in ground water levels from post to pre-monsoon period can be assigned due to excess with drawl of water (overdraft) amount and intensity of rainfall and the nature of topography. The fluctuation ranges of 2 m (Sajwani, Talun, Talun Govt., Piplaj and Bajrikheda) to 10 m (Barwani, Sajwani, Sajwani and Lonsara) have been recognized during the post- and pre-monsoon periods.

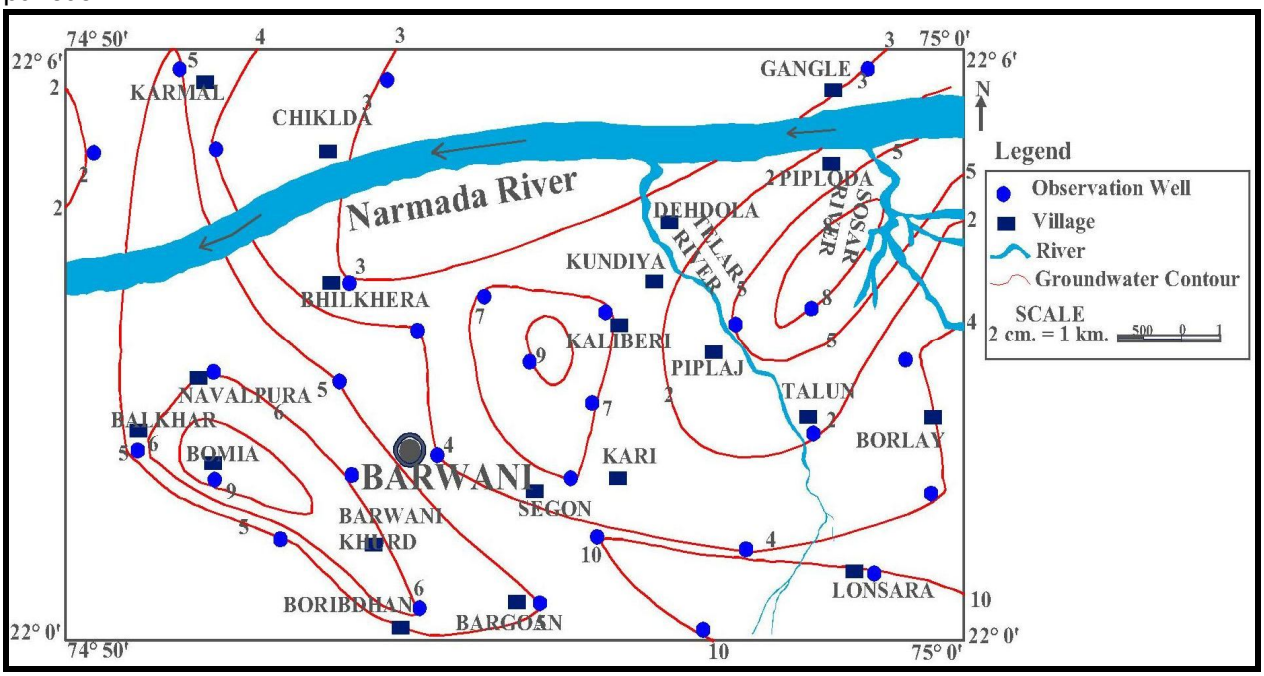

Fig. 4: Fluctuation map of ground water level contour map of Barwani study area

4. CONCLUSION

The paper has recorded results of the seasonal variation analysis of static ground water levels measured from the open dug wells existing in the vicinity of Barwani area. The trend of water levels enables to delineate the characterization of aquifer. It has been observed that the potential ground water sites for the constructions of additional dug wells must be constructed at the locations revealing the minimum fluctuation of 2 to 4 m. b.g.l. in the seasonal ground water levels in and around Sajwani, Talun, Piplaj, Bajrikheda, Bhilkheda, Barwani, Lonsara, Borlai, Kaperkheda, Sisgone and Gonglle.

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