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Research Paper

HYDROGEOLOGICAL CONDITIONS IN PARTS OF UTTARA KANNADA DISTRICT, KARNATAKA

Davithuraj J[1], Raju Sukhaye[2] and Manjunatha S[2]*

Corresponding Author: **Manjunatha S ✉ manjunathas29@yahoo.in*

A total of 55 key observation wells were established in different hydrogeological setting in Uttara Kannada district to study the groundwater conditions. Based on the study, groundwater occurs under unconfined, semi-confined and confined conditions in the weathered and fractured zones of granitic gneiss, metagraywackes, schists and laterites. Pre-monsoon depth to water level map reveals that water range from 5-10 m bgl. Post monsoon depth to water level map indicates the dominance of 2 -5 m bgl depth. A perusal of the water level fluctuation map shows two dominant fluctuation ranges of 0-2 m and 2-4 m, which are almost equally distributed. As per long term water level trend analysis, the data from the hydrograph station at Joida, Yellapur, Khumbarwada, Anashi and Dandeli shows rising trend for both pre-monsoon and post-monsoon period. Hydrograph station data of Barlgod shows rising trend for pre-monsoon period and falling trend for post monsoon period. Whereas the hydrograph station data of Haliyal shows falling trend for both pre-monsoon and post-monsoon period. These are the places where augmentation to groundwater is required to arrest the decline in water level by adopting artificial recharge practices.

Keywords: Hydrogeology, Pre-monsoon, Post-monsoon, Uttara Kannada, Karnataka

INTRODUCTION

Hydrogeology deals with the occurrence, distribution and subsurface water. The drainage pattern, land use, marshy conditions and infiltration of surface water through soil, fractured and weathered bedrock influence the groundwater potential of an area. The main source of ground water occurring in the basin area is through precipitation and return flow from applied irrigation. The ground water occurrence and movement are controlled by the degree of weathering, fracturing and the geomorphological set up in the area. In general the ground water in the area occurs under phreatic condition and semi confined condition in weathered and jointed formations. Hydrogeologically, the study area is represented by the presence of two geological formations, i.e., the peninsular gneissic complex of Achaeans and meta volcano-sedimentary sequence of Dharwar super group. Hydrogeological conditions of ground water have been studied in different parts of the county

[1] CGWB, SUO, Belgaum - 590 019, India.
[2] Department of Geology, Karnatak Science College, Dharwad - 580 001, India.

(Reddy, 2013, 2012b; Davithuraj and Manjunatha, 2013; Pandurang Patil and Praveen, 2012; Babar and Kaplay, 2003; Sukumar and Sankar, 2011 and Abbi, 1991). The present paper deals with water bearing properties of these formations, occurrence and movement of ground water, depth to water during pre and post monsoon, seasonal fluctuations, long term ground water level behavior, aquifer parameters of these formations have been dealt in detail.

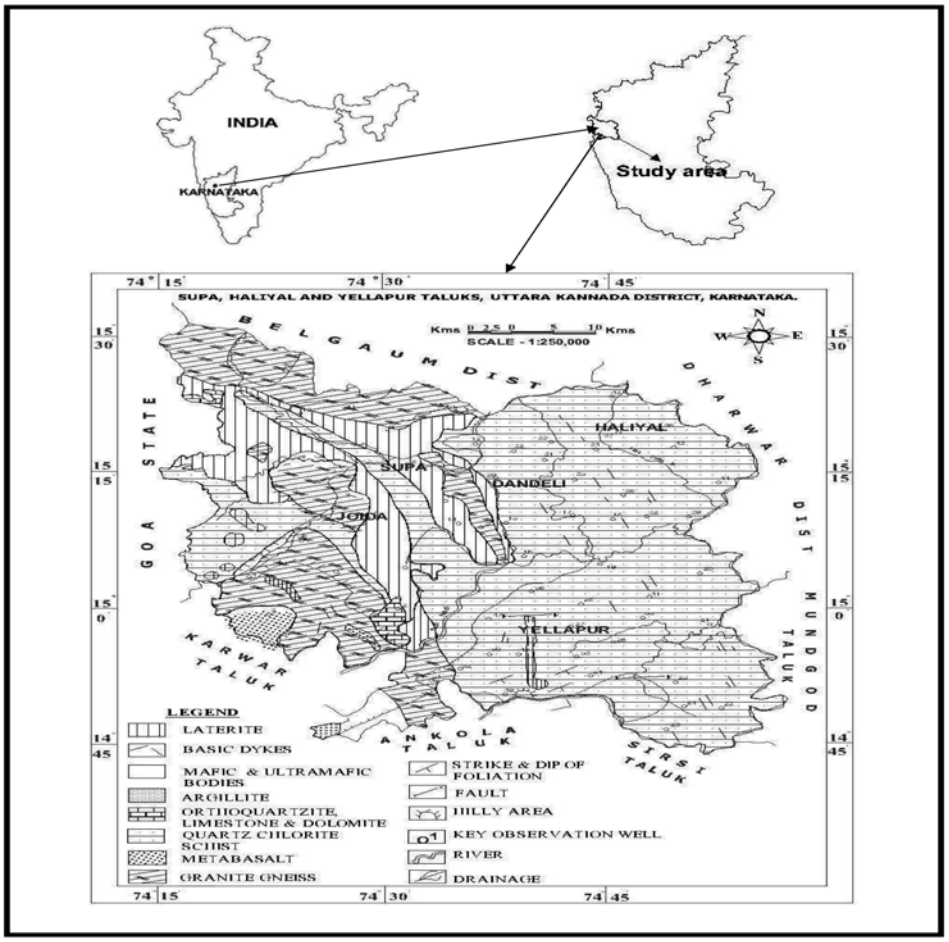
STUDY AREA

The study area comprises of three adjacent taluks, viz; Haliyal, Joida and Yellapur of Uttara Kannada district and covering an area of 4,050 km^2. These taluks falls in the northern part the Uttara Kannada district. The area is bounded by latitudes 14°45'00" N and 15°31'30" N, and between Longitudes 74°15'00"E and 74°56'30"E, which falls in the survey of India toposheet No. 48I/5, 48I/6, 48I/7, 48I/8, 48I/11, 48I/12, 48I/15, 48I/16, 48J/9 and 48J/13. Administratively, the area is bounded on East by Dharwad district and Mudgod taluk of Uttatra Kannada district, on North by Belgaum district, on the south by Karwar taluk of Uttara kannada district and on West by Goa state.

GEOLOGY

Geologically, the area is underlained by the

Figure 1: Geological Map of Study Area



peninsular gneissic complex of Archaeans and meta volcano- sedimentary sequence of Dharwar super group and younger intrusive at granites. All these lithounits have been intruded by basic and acid dykes. During the sub-recent to recent age these rocks have undergone lateritisation resulting in a cover of laterite varying thickness. Alluvial deposits of sub-recent to recent age of limited thickness and extension occur along the major drainage courses of Kali river and Bedti river. The peninsular gneissic rocks mainly comprises of granite gneisses and migmatite. The basic dykes (gabbro and dolerite) are common intrusive, especially in the eastern and southern sectors of the area. The geology of the area is shown in Figure 1.

METHODOLOGY

Fifty five key observation wells were established in different hydrogeological settings spread over the area. The hydrogeological details are presented in Table 1. To study the present ground water regime of the area, the pre- and post-monsoon water level were monitored. The pre and post-monsoon water table map was also prepared. The historical water level data of observation wells was utilized to analyze the long-term water level trend. To decipher, the existing ground water level scenario, the pre monsoon and post-monsoon water level data of key wells spread throughout the area and appropriately representing all the formations monitored in May and November 2011 respectively was utilized.

DRAINAGE

The study area is drained by two major rivers, viz; Kali and Bedti. Kali river takes its birth in Diggi, a small village in Joida taluk. It flows at the beginning in a southeasterly direction and south west for a length more than 50 km and takes a sudden turn towards west and flows up to the confluence with Arabian sea. The entire area of Haliyal and Joida taluks are being drained by Kali river and its tributaries. The drainage pattern of the river is controlled by the structural features. Generally, the drainage pattern of the river is dendritic to sub dendritic. Bedti river is a major river flowing in the southern part of the area, which flows in southern and south western direction. Yellapur taluk is drained by Bedti river and its tributaries. All these rivers start from the Western Ghats and flow towards west and ultimately join the Arabian Sea.

SOILS

The most rugged hilly parts of the area are covered by hilly type soil and surrounded by the areas covered by lateritic soil having less rugged feature. Alluvial soil is occurring along the river bank. On eastern parts, the lateritic soils change to red loamy soils. These types of soils cover major part of the area in Haliyal and Yellapur taluks.

RAINFALL

In order to study the rainfall pattern of the area, time series analysis of annual rainfall data from Haliyal, Joida and Yellapur have been carried out for the periods from 2002-2011. The rainfall received show wide variation seasonally and major share of the annual precipitation is received from southwest monsoon, which is active during June-September months. It is seen that seasonal distribution of rainfall is more or less similar in all rain gauge stations. The Southwest monsoon accounts for 85% of annual rainfall, whereas the

Table 1: Hydrogeological Details of the key Observation Wells of Haliyal, Supa and Yellapur Taluks of Uttrakannada District (2011-12)

S.No.	Village	Taluk	Topo Sheet No.	Type of well / use	Lifting device	Depth of well (m bgl)	Dia. of the well (m)	Type of aquifer	DTW (m bgl)		Fluctuation (m)
									Pre monsoon	Post monsoon	
1	2	3	4	5	6	7	8	9	10	11	12
01	Marada	Supa	48I/12	DW/D	R&B	8.30	2.00	Laterite	5.20	2.82	2.38
02	Ulvi	Supa	48I/12	DW/D	R&B	6.20	1.60	Laterite	5.32	3.72	1.60
03	Anashi	Supa	48I/5	DW/D	R&B	10.56	2.50	Laterite / Wt.Gr.Gn	9.49	3.76	5.73
04	Nunji	Supa	48I/8	DW/D	R&B	9.25	2.0	Laterite	6.31	1.86	4.45
05	Kalasai	Supa	48I/8	DW/D	R&B	7.60	1.90	Laterite / Wt.Gr.Gn	2.81	0.67	2.14
06	Khumbhar-wada	Supa	48I/8	DW/D	R&B	9.00	2.50	Laterite / Wt.Gr.Gn	7.68	5.16	2.52
07	Joida	Supa	48I/8	DW/D	R&B	8.25	4.00	Laterite	7.04	2.32	4.72
08	Jagalbhet	Supa	48I/11	DW/D	R&B	5.00	2.00	Laterite / Wt.Gr.Gn	3.92	0.92	3.00
09	Kambra	Supa	48I/7	DW/D	R&B	8.54	2.00	Wt.Gr.Gn	8.40	4.76	3.64
10	Borehalli	Supa	48I/7	DW/D	R&B	4.26	2.50	Wt.Gr.Gn	3.10	1.32	1.78
11	Barchi	Supa	48I/11	DW/D	R&B	15.48	2.50	Wt.Meta greywack	10.26	5.38	4.88
12	Pradheni	Supa	48I/12	DW/D	R&B	5.00	2.00	Laterite	3.52	1.92	1.60
13	Virnoli	Supa	48I/12	DW/D	R&B	6.00	2.00	Laterite	4.24	1.42	2.82
14	Kulgi	Haliyal	48I/12	DW/D	R&B	5.50	2.00	Wt.Gr.Gn	4.31	1.76	2.55
15	Ambika Nagar	Haliyal	48I/12	DW/D	R&B	5.50	2.00	Wt.Gr.Gn	4.34	1.81	2.53
16	Bomman-halli	Haliyal	48I/12	DW/D	R&B	12.17	2.00	Laterite/ Wt.Meta greywack	9.71	7.41	2.30
17	Bhagavati	Haliyal	48I/16	DW/D	R&B	15.45	3.00	Wt.Meta greywack	9.47	2.76	6.71
18	Tatwal	Yellapur	48I/12	DW/D	R&B	9.58	1.75	Wt.Schist	5.71	3.86	1.85
19	Kirvati	Yellapur	48I/6	DW/D	R&B	12.00	1.95	Wt.Schist	10.25	6.26	3.99
20	Sidalgundi	Yellapur	48J/13	DW/D	R&B	6.70	2.10	Wt.Schist	5.19	2.00	3.19
21	Barathalli	Yellapur	48J/13	DW/D	R&B	6.80	1.20	Wt.Schist	5.37	2.97	2.40
22	Chavati	Yellapur	48J/13	DW/D	R&B	12.50	2.10	Wt.Schist	12.13	9.58	2.55
23	Umachi	Yellapur	48J/13	DW/D	R&B	15.00	2.30	Wt.Schist	13.80	10.88	2.92

Table 1 (Cont.)

S.No.	Village	Taluk	Topo Sheet No.	Type of well / use	Lifting device	Depth of well (m bgl)	Dia. of the well (m)	Type of aquifer	DTW (m bgl)		Fluctuation (m)
									Pre monsoon	Post monsoon	
24	Manchikeri	Yellapur	48J/13	DW/D	R&B	17.40	2.55	Wt.Schist	16.31	14.42	1.89
25	Savabgeri	Yellapur	48J/9	DW/D	R&B	10.40	2.00	Wt.Schist	6.31	3.52	2.79
26	Yellapur	Yellapur	48J/9	DW/D	R&B	10.25	2.50	Wt.Schist	7.11	5.41	1.70
27	Kannigeri	Yellapur	48I/12	DW/D	R&B	6.50	2.00	Wt.Schist	5.81	1.50	4.31
28	Dandeli	Supa	48I/12	DW/D	R&B	6.12	2.00	Wt.Gr.Gn	1.97	1.47	0.50
29	Pansoli	Supa	48I/12	DW/D	R&B	10.62	5.00	Laterite/ Wt.Gr.Gn	7.87	2.96	4.91
30	Alur	Haliyal	48I/11	DW/D	R&B	7.26	2.50	Wt.Meta greywack	2.92	1.32	1.60
31	Shirgur	Haliyal	48I/11	DW/D	R&B	14.69	2.50	Wt.Gr.Gn	13.17	3.38	9.79
32	Ajgaon	Haliyal	48I/11	DW/D	R&B	11.17	2.50	Wt.Gr.Gn	9.44	3.56	5.88
33	Kasaroli	Haliyal	48I/11	DW/D	R&B	9.67	2.40	Wt.Meta greywack	5.48	1.02	4.46
34	Gardoli	Haliyal	48I/11	DW/D	R&B	7.35	1.85	Wt.Meta greywack	6.47	2.10	4.37
35	Sambrani	Haliyal	48I/16	DW/D	R&B	12.74	2.50	Wt.Meta greywack	11.48	8.82	2.66
36	Haliyal	Haliyal		DW/D	R&B	9.86	5.00	Wt.Meta greywack	8.78	3.46	5.32
37	Pandarval Hosur	Haliyal	48I/16	DW/D	R&B	12.11	2.50	Wt.Meta greywack	9.32	9.32	1.52
38	Tattageri	Haliyal	48I/16	DW/D	R&B	7.56	2.50	Wt.Meta greywack	5.10	5.10	1.12
39	Barlgod	Supa	48I/2	DW/D	R&B	11.80	2.00	Wt.Gr.Gn	11.01	6.22	4.79
40	Domgeri	Yellapur	48I/16	DW/D	R&B	11.50	2.50	Wt.Schist	10.26	5.26	5.00
41	Madanalli	Haliyal	48I/11	DW/D	R&B	9.00	2.00	Wt.Meta greywack	8.37	2.76	5.61
42	Negashetti Koppa	Haliyal	48I/15	DW/D	R&B	9.50	2.50	Wt.Meta greywack	6.41	1.98	4.43
43	Belvategi	Haliyal	48I/15	DW/D	R&B	12.15	3.00	Wt.Meta greywack	8.80	1.87	6.93
44	Hampehalli	Haliyal	48I/16	DW/D	R&B	7.12	2.00	Wt.Meta greywack	6.82	0.73	6.09
45	Kanchanhalli	Haliyal	48I/15	DW/D	R&B	12.63	2.30	Wt.Meta greywack	10.26	4.28	0.80
46	Dehalli	Yellapur	48J/9	DW/D	R&B	11.00	2.00	Wt.Schist	10.35	5.36	4.99
47	Iagundi	Yellapur	48J/9	DW/D	R&B	10.26	1.65	Wt.Schist	5.75	3.26	2.49
48	Arabail	Yellapur	48J/9	DW/D	R&B	10.65	2.15	Wt.Schist	7.56	7.43	0.13
49	Telanger	Yellapur	48J/9	DW/D	R&B	8.00	2.10	Wt.Schist	4.87	2.68	2.19

Table 1 (Cont.)

S.No.	Village	Taluk	Topo Sheet No.	Type of well / use	Lifting device	Depth of well (m bgl)	Dia. of the well (m)	Type of aquifer	DTW (m bgl)		Fluctuation (m)
									Pre monsoon	Post monsoon	
50	Basal	Yellapur	48J/9	DW/D	R&B	8.90	2.05	Wt.Schist	8.05	6.72	1.33
51	Vajralli	Yellapur	48J/9	DW/D	R&B	12.65	2.00	Wt.Schist	11.55	8.62	2.93
52	Nandolli	Yellapur	48J/9	DW/D	R&B	14.10	1.65	Wt.Schist	10.20	8.92	2.93
53	Magod	Yellapur	48J/9	DW/D	R&B	11.90	2.00	Wt.Schist	7.26	4.41	2.85
54	Hunshetti koppa	Yellapur	48J/13	DW/D	R&B	10.50	2.15	Wt.Schist	10.36	1.97	8.39
55	Gear	Yellapur	48I/12	DW/D	R&B	8.50	2.50	Wt.Schist	6.12	3.85	2.27

Note: DW/D: Dug well/ Domestic. R&B: Rope & Bucket. Wt. Gr. Gn: Weathered Granitic Gneiss, Wt. Schist: Weathered Schist, Wt. Meta greywack: Weathered Meta greywacke.

winter rainfall contributes about 8 to 10%. The balance is received during pre-monsoon period.

The statistical parameters computed for rainfall recorded for Haliyal, Yellapur and Joida rain gauge stations are given below in Table 2**.** The standard deviation and co-efficient variation of annual rainfall for Haliyal, Yellapur and Joida rain gauge stations are estimated from 10 years data. The year on which the maximum and minimum rainfall recorded during this period shows variations for different rain gauge stations.

RESULTS AND DISCUSSION

Hydrogeology

Granitic gneiss occurs in the south west and extreme northern parts of the study area. The granitic gneiss varies widely in their water bearing properties. They do not have intergranular primary openings. Fresh crystalline rocks have less than 1% porosity and permeability is negligible. In the granitic gneiss, the groundwater occurs under an unconfined, semi-confined and confined conditions in the weathered and fractured zones.

Table 2: Statistical Data on the Rainfall at Haliyal, Yellapur and Joida Taluks

Statistical analysis of rainfall data (IMD Station)				
S.No.	**Particulars**	**Haliyal**	**Joida**	**Yellapur**
1	No. of years of data analysed	10	10	10
2	Maximum RF in mm (YEAR)	1360.5 (2005)	3182.2(2005)	3318 (2006)
3	Minimum RF in mm (YEAR)	877.6(2002)	1815 (2002)	1939(2002)
4	Average annual RF in mm	1206.1	2415.2	2645.9
5	Standard Deviation (SD)	217	460	411
6	Co-efficient variation of annual rainfall %	17.98	19.03	15.73

The laterites and the near surface weathered and jointed zones of granitic gneiss and associated rocks together constitute the main water table aquifer. The water in the phreatic aquifer occurs in near surface strata, generally down to the depth of about 10 to 20 m bgl in weathered, jointed and fractured formations.

The schistose rocks occur in the south west and eastern parts of the study area. They contribute to about 60% of rocks of the study area. The groundwater occurs in the semi-confined condition in the weathered and fractured zones of metagraywackes and schists, where they are overlain by laterites with lithomarge serving as a confining layer. The water bearing zone occurs at a depth of about 15 to 40 m bgl.

Laterites mainly occurs in the hilly areas and generally having a thickness of about 10 to 30 m bgl. On high ground, 1 to 2 m bgl of laterite is very hard, ferruginous, iron black in color, grading downwards into soft grayish or reddish colored. At some places the laterites are more clayey and aluminous in character. The low level secondary laterite of undoubted detrital origin offers an ideal venue for groundwater through its opening and loosely cemented zones. Besides the inherent porosity, the laterites are highly jointed and fractured, which further enhances their water bearing capacity. During monsoon the rock formations get saturated quickly. However the desaturation is also equally quick once the monsoon is over.

In the alluvium formation, the groundwater occurs under phreatic and semi confined condition in the granular zones comprising of medium to coarse sands, gravels, pebbles and boulders. The groundwater accumulation in granular interstices is directly proportional to the granular zones, i.e., the groundwater accumulation will be higher in coarser formation and the formation clear of clayey admixture or intercalation.

PRE-MONSOON DEPTH TO WATER LEVEL

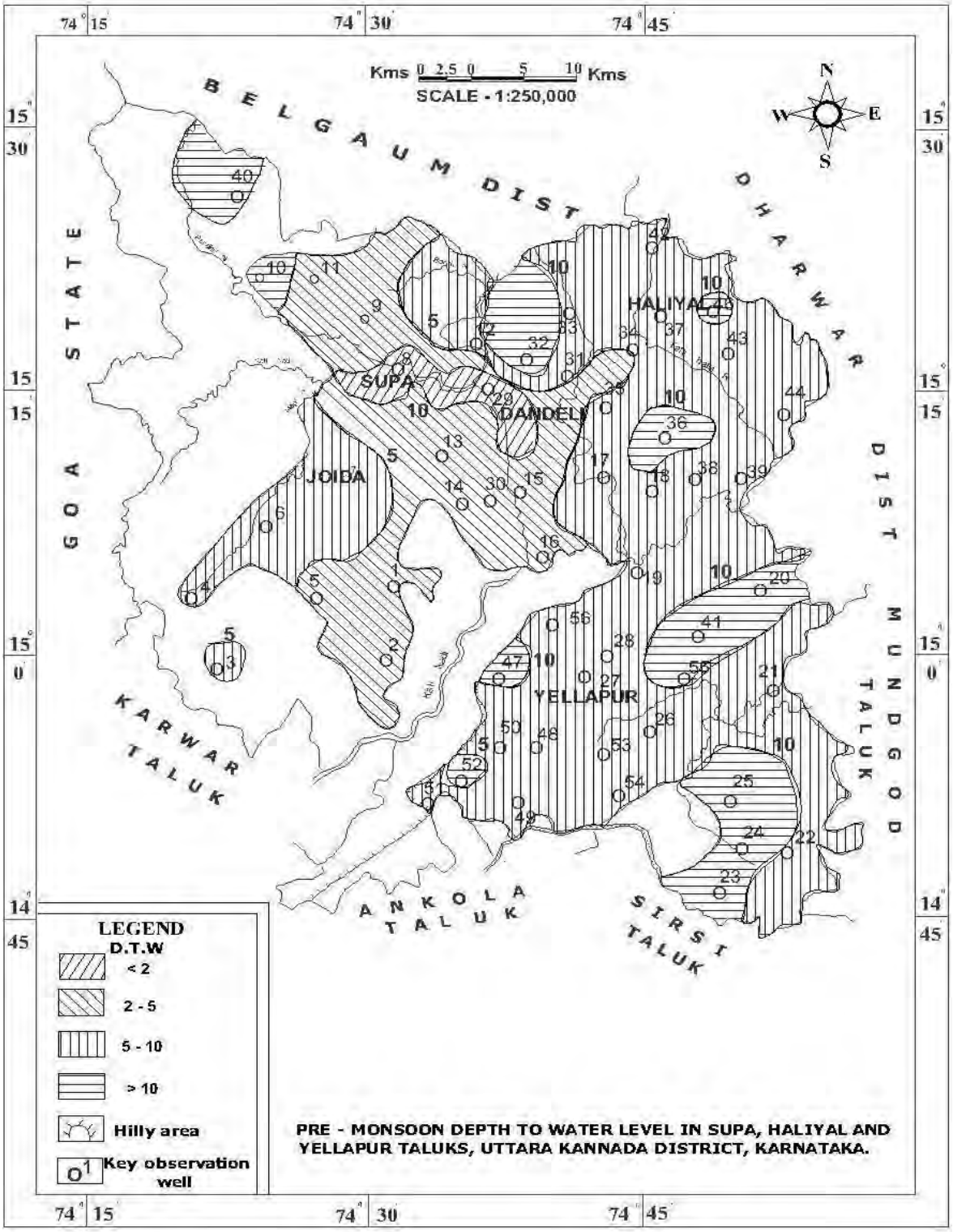
The pre monsoon depth to water level of the key observation wells was monitored in May 2011. The data pertaining to number of wells falling in each depth to water ranges in all types of aquifer was analyzed and the percentage of wells in each category was also calculated and is presented in Table 3. The data of pre monsoon depth to water level was plotted in the map and is presented in Figure 2.

The perusal of the map reveals that major part of the area in the east, south and north falls in depth to water range of 5-10 m bgl. The next major

Table 3: Aquifer wise Depth to Water Ranges with Percentage During Pre Monsoon Season

S. No	Aquifer	Depth to water range in m with percentage			
		0 to2	2 to5	5to10	>10
1	Granitic gneisses	07	36	50	07
2	Metagreywake	00	17	39	44
3	Schist	00	10	50	40
4	Laterite	00	50	50	00

Figure 2: Pre Monsoon Depth to Water Level of Study Area



depth to water level range of 2-5 m bgl occurs in central and north-central parts of the area. The deeper depth to water ranges of more than 10 m bgl are restricted in the extreme southern parts around Umachi and Manchikeri area. Two small isolated patches are also having depth to water level more than 10 m bgl, i.e., around Kirvati and Domegeri of Yellapur taluk and Sambrani village of Haliyal taluk. The area around Ganeshgudi of Joida taluk is having depth to water range less than 2 m bgl. The shallows depth to water in this area can be attributed to the presence of supa reservoir.

POST-MONSOON DEPTH TO WATER LEVEL

The post monsoon depth to water was monitored in October-November 2011. The data showing different depth to water ranges and number of wells occurring in these ranges in different aquifers types is presented in Table 4.

Post-monsoon depth to water was also plotted on map and the map is presented in Figure 3. The perusal of the map shows the dominance of 2-5 m bgl depth to water range in major part of the area as in the pre-monsoon season. Within this range about 70% of the area being occupied Schistose rock in the eastern southeastern parts. The depth to water range of >10 m bgl occurs around Umachi and Manchikeri of Yellapu taluk.

GROUNDWATER FLUCTUATION

The seasonal fluctuation is derived from the difference in pre and post-monsoon water level. The seasonal fluctuation obtained was classified into different ranges from less than 2 m to more than 5 m. The seasonal fluctuations are also

Table 4: Aquifer wise Depth to Water Ranges with Percentage During Post Monsoon Season

S. No	Aquifer	Depth to water range in m with percentage			
		0 to2	2 to5	5to10	>10
1	Granitic gneisses	42	29	29	00
2	Metagreywake	34	44	22	00
3	Schist	15	40	35	10
4	Laterite	50	50	00	00

Table 5: Aquifer wise Ranges of Depth, Diameter, Pre Monsoon and Post Monsoon Water Levels and Fluctuation in Key Wells

S. No	Aquifer	Depth	Pre monsoon Water level	Post monsoon Water level	Seasonal Fluctuation
		m bgl	m bgl	m bgl	m
1	Granitic gneisses	4.26 – 14.69	1.97-13.17	0.67-6.22	0.50 – 9.79
2	Metagreywake	2.50 -15.48	2.92 - 11.48	0.73-9.32	0.80- 6.93
3	Schist	6.50-17.40	4.87-16.31	1.50-14.42	0.13-8.39
4	Laterite	5.00 – 12.17	2.81 – 9.71	0.67-7.41	1.60 – 5.73

Figure 3: Post Monsoon Depth to Water Level of Study Area

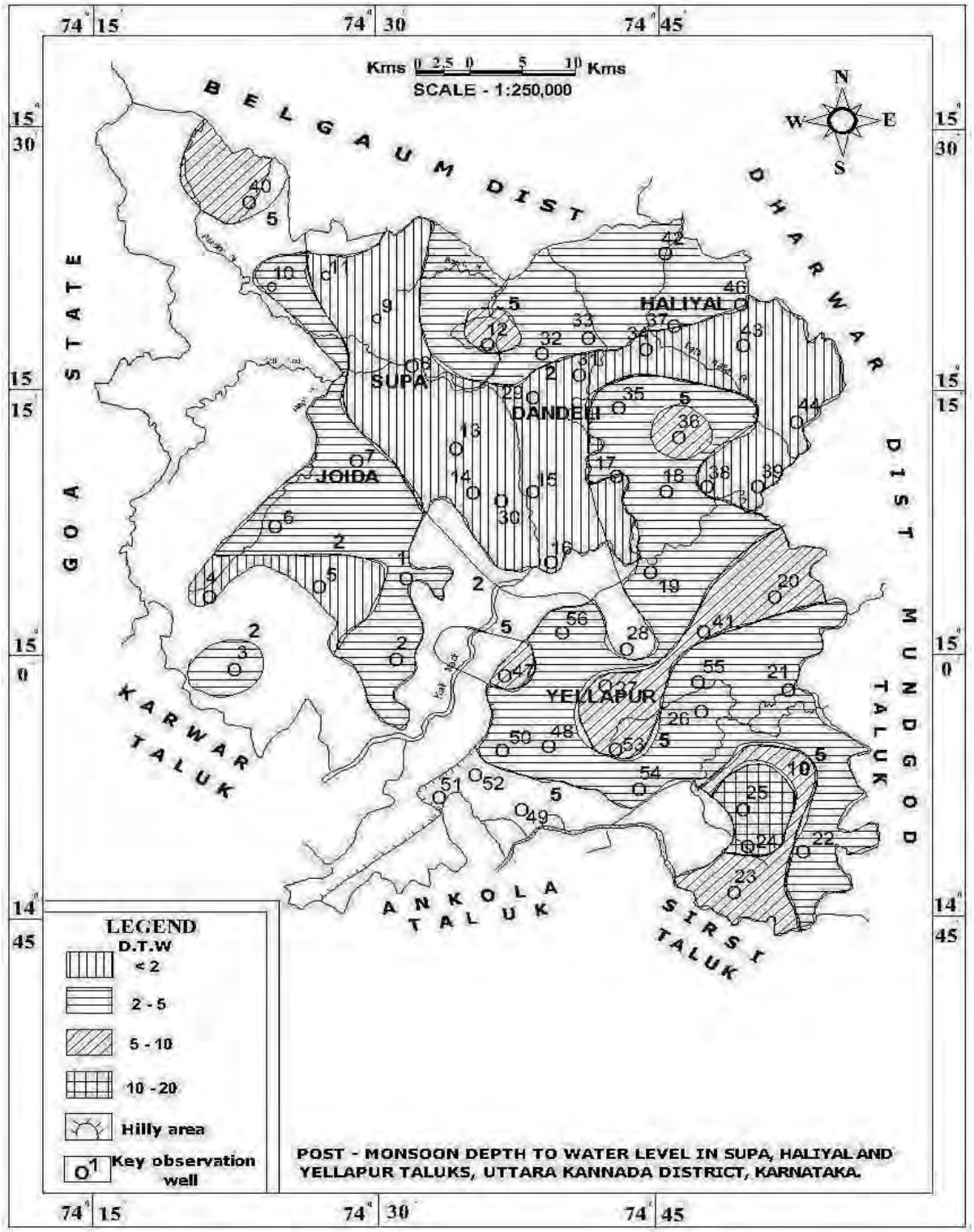
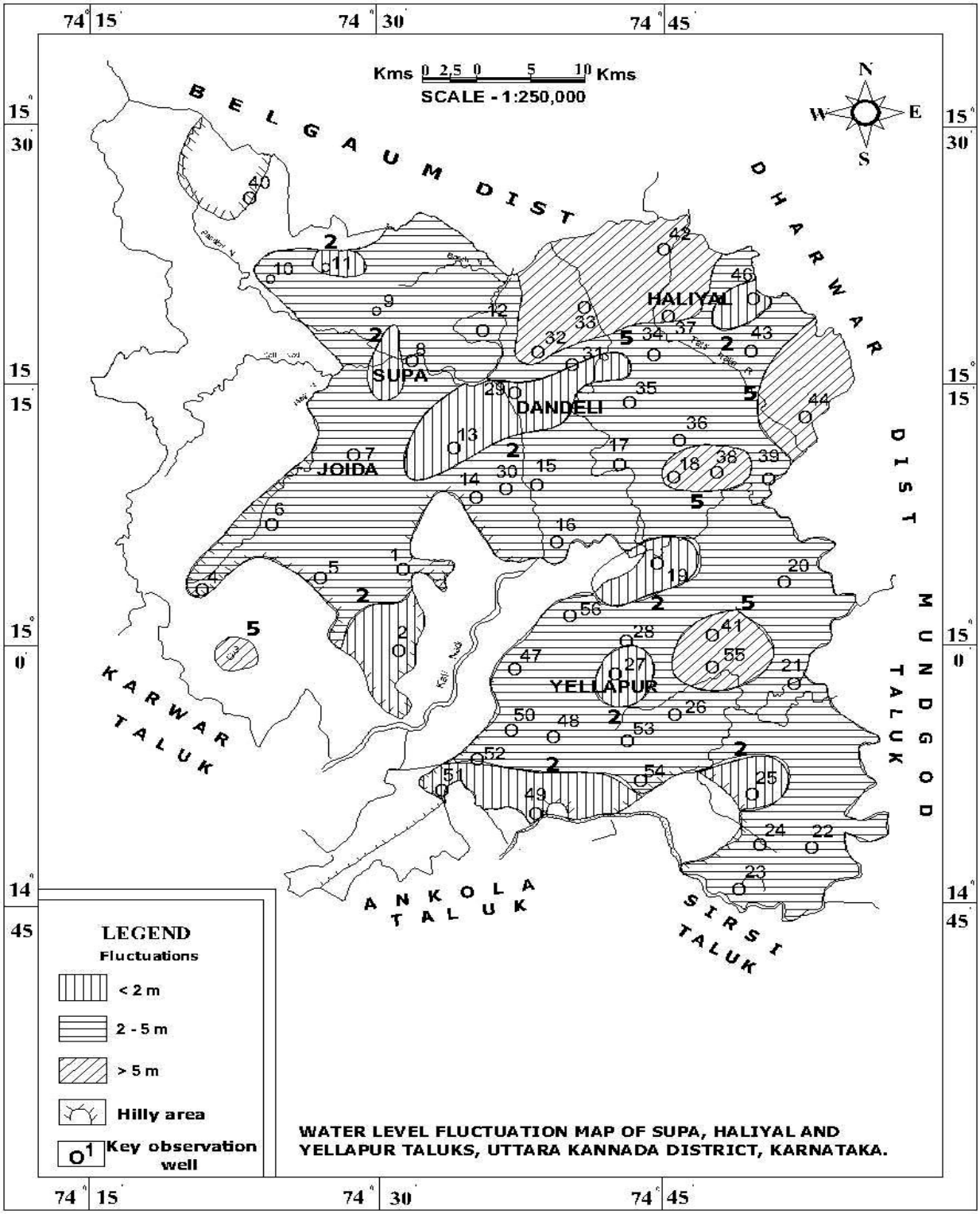


Figure 4: Water Level Fluctuation in Study Area



plotted on the map and are presented in Figure 4. The perusal of the map shows 2 dominant fluctuation ranges of 0-2 m and 2-4 m, which are almost equally distributed and represented in the Table 5.

LONG TERM WATER LEVEL TREND

Ground water is a renewable resource. It gets depleted when the aquifer is over drafted. The aquifer gets recharged during monsoon period. Rainfall is the main source of recharge to ground water. In order to study the long-term trends of ground water level in the area, water level data have been analyzed for 7 NHS observation wells for pre-monsoon and post-monsoon established for the periods from May 2002 to November 2011 and is shown in Table 6. The results of hydrographs of the observation wells are shown in Figure 5 (a to g).

Joida, Yellapur, Khumbarwada, Anashi and Dandeli hydrograph stations shows rising trend of ranges from 0.026 to 0.218 m/year for pre-monsoon and 0.009 to 0.0.276 m/year for post-monsoon respectively. Barlgod hydrograph station shows rising trend of 0.293 m/year for pre-monsoon and falling trend of 0.046 m/year for post

Table 6: Long Term Water Level Trends

S. No.	Location	Period of Observation	Water level trend m/year			
			Pre monsoon		Post monsoon	
			Fall	Rise	Fall	Rise
1	Dandeli	2002-2011		0.151		0.276
2	Haliyal	2002-2011	0.536		0.310	
3	Barlgod	2002-2011		0.293	0.046	
4	Joida	2002-2011		0.218		0.009
5	Khumbarwad	2002-2011		0.080		0.016
6	Anashi	2002-2011		0.207		0.124
7	Yellapur	2002-2011		0.026		0.159

Figure 5 (a): Hydrograph of Dandeli area

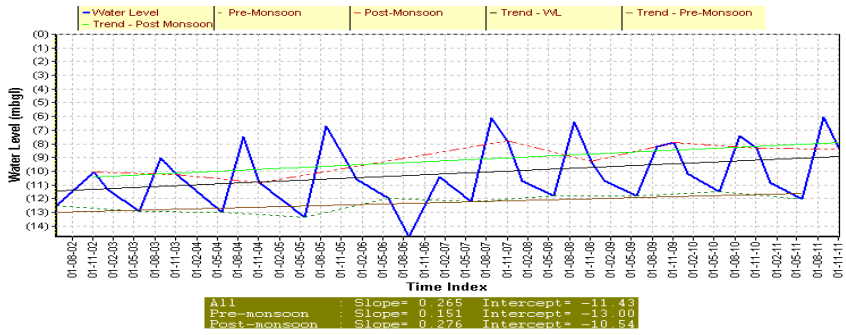


Figure 5 (b): Hydrograph of Haliyal area

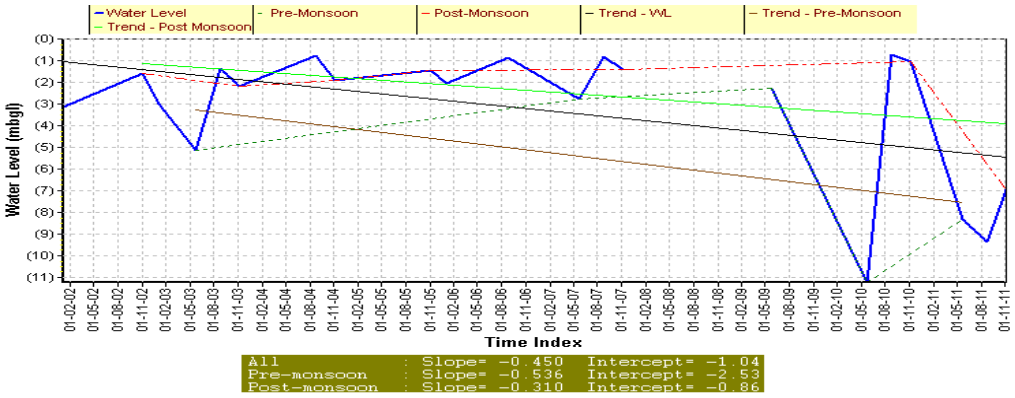


Figure 5 (c): Hydrograph of Baralgod area

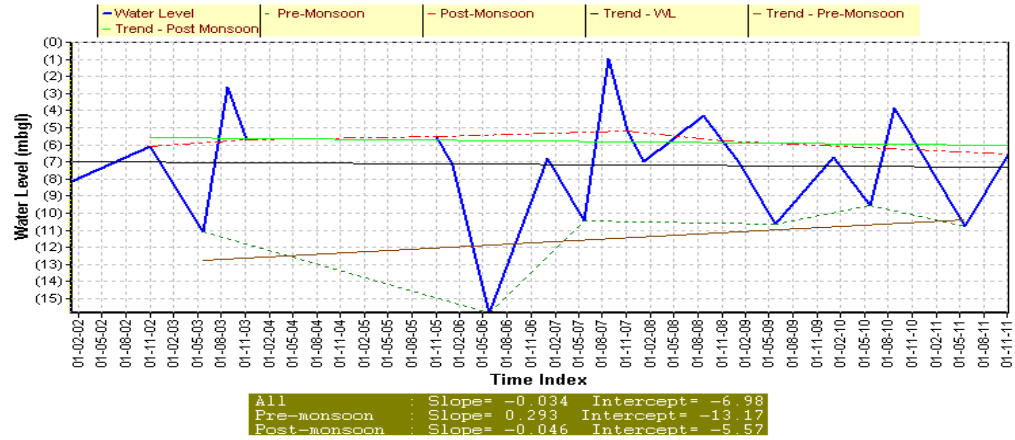


Figure 5 (d): Hydrograph of Joida Area

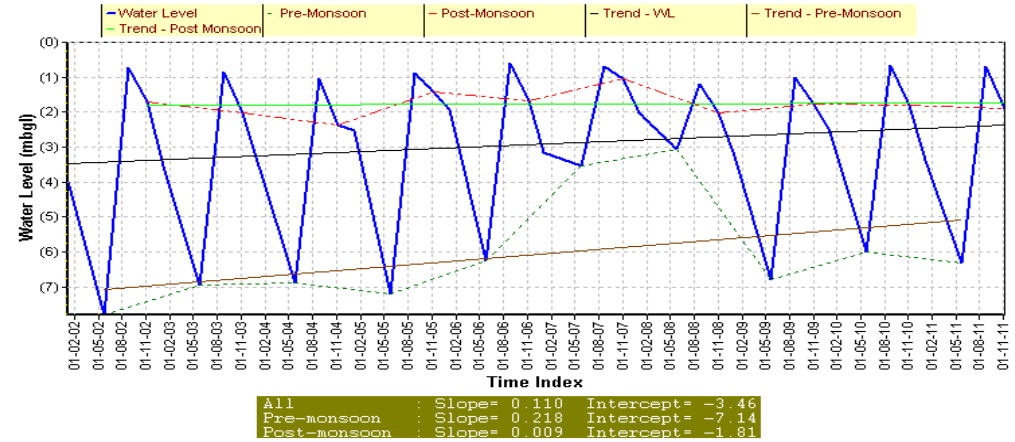


Figure 5 (e): Hydrograph of Kumbarwada area

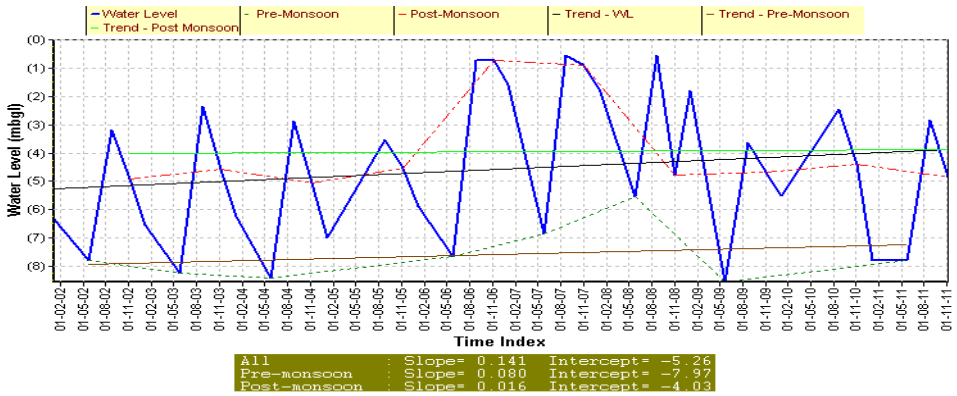


Figure 5 (f): Hydrograph of Anashi Area

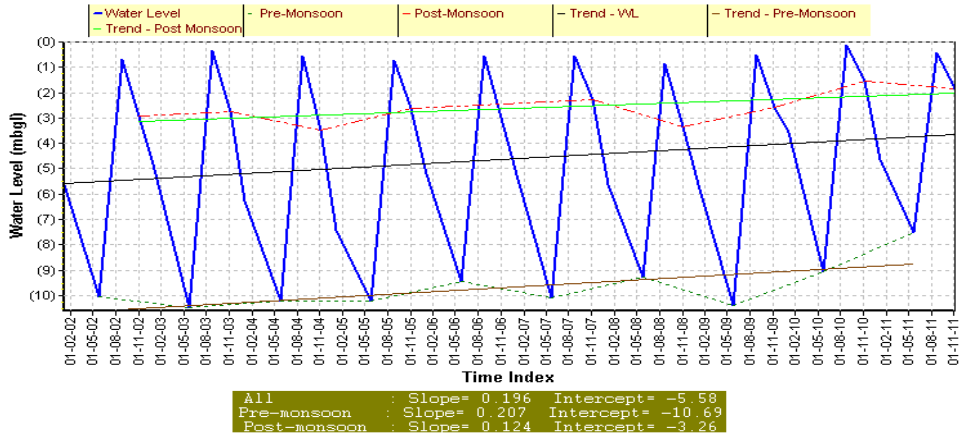
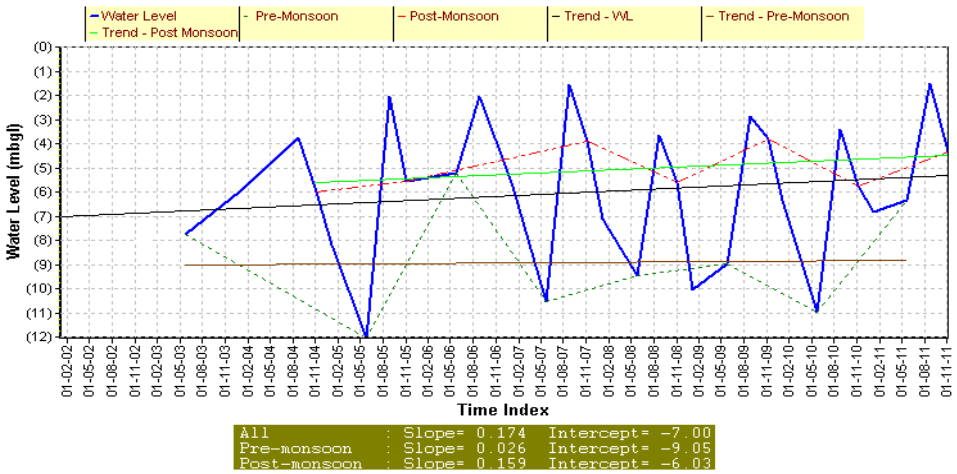


Figure 5 (g): Hydrograph of Yellapur Area



monsoon. Haliyal hydrograph stations shows falling trend of 0.536 m/year for pre-monsoon and 0.310 m/year for post-monsoon. These are the places where augmentation to ground water is required to arrest the decline in water level by adopting artificial recharge practices.

CONCLUSION

Hydrogeologically, the area is represented by the presence of two geological formations i.e the peninsular gneissic complex of Achaeans and meta- sedimentary sequence of Dharwar super group. The main source of ground water occurring in the area is through precipitation and return flow from applied irrigation. Ground water occurs under unconfined, semi-confined and confined conditions in the weathered and fractured zones of granitic gneiss, schists, metagraywackes and laterites. The water in the granitic geniss generally occurs down to the depth of about 10 to 20 m bgl. In the schistose formations the water bearing zone occurs at a depth of about 15 to 40 m bgl. Laterite mainly occurring in hilly area generally varies in thickness from 10 to 30 m bgl and 1 to 2 m bgl on high ground. During monsoon the rock gets saturated quickly. However, de-saturation is also equally quick, once the monsoon is over.

Pre-monsoon depth to water level map reveals that major part of the area in the east, south and north falls in depth to water range of 5-10 m bgl. The next major depth to water level range of 2-5 m bgl occurs in central and north-central parts of the area. Post-monsoon depth to water level map depicts that same pattern as observed during pre-monsoon period. Post monsoon depth to water level map indicates that the dominance of 2-5 m depth to water range in major part of the area. The perusal of the water level fluctuation map shows two dominant fluctuation ranges of 0-2 m and 2-4 m, which are almost equally distributed. As per long term water level trend analysis is concerned, the data from the hydrograph stations at Joida, Yellapur, Khumbarwada, Anashi and Dandeli shows rising trend from 0.026 to 0.218 m/year for pre-monsoon and 0.009 to 0.027 m/year for post-monsoon respectively. Data from the Barlgod hydrograph station shows rising trend of 0.293 m/year for pre-monsoon and falling trend of 0.046 m/year for post-monsoon. Whereas the hydrograph station data from Haliyal shows falling trend of 0.536 m/year for pre-monsoon and 0.310 m/year for post-monsoon. These are the places where augmentation to ground water is required to arrest the decline in water level by adopting artificial recharge practices.

REFERENCES

1. Abbi A K (1991), “Hydrogeological study of Tuparihalla basin, Karnataka, India”, Unpublished Ph.D. thesis Karnataka University, Dharwad.
2. Babar Mohammad and Kaplay R D (2003), “Groundwater fluctuation in Purna river basin parbhani district, Maharashtra”, *Journal of applied hydrology,* Vol. XVI, No. 1, pp. 56-61.
3. Davithuraj and Manjunath (2014), “Groundwater fluctuation in upper Bennihalla basin, Karnataka”*, International Journal of Applied Research.* Vol. 4, issue 3.
4. Patil Pandurang and Saptarshi Praveen (2012), “Groundwater fluctuation in the Pondhra watershed basin of Karmala Tahsil, Solapur (MS)”, *Universal Journal of Environmental Research & Technology*, Vol. 2, issue 5.

5. Reddy A G S (2012), "Groundwater management studies in north western parts of Thane district, Maharashtra", Central Ground Water Board, CR, Nagpur.

6. Reddy A G S (2013), "Contradictory water level conditions & groundwater potentialities in basalts - A case study in mid-western parts of Thane district of Maharashtra", *International Journal of Earth Sciences & Engineering*, Vol. 6, No. 5 (01), pp .1129-1142.

7. Sukumar S and Sankar K (2011), "Statistical study on pre & post monsoon variation of groundwater level in Theni district, Tamil Nadu, India"*, International Journal of Environmental Sciences*, Vol. 1, No. 5.