



GROUND WATER LEVEL VARIATIONS, FLUCTUATION RECHARGE AND POTENTIAL OF THE TAMILNADU STATE

Dr. M. Parusuram Naik* Dr. A. Krishna Kumari*
*Department of Geography, SK University, Andhra Pradesh.

Abstract

The Tamilnadu state covering an area about 1.3 lakhs sq.km has been studied taking monthly ground water level data from about 51 controlled wells for a period of ten years. From the monthly average ground water level variations the fluctuations are worked out on seasonal and annual basis. From the analysis it is found that the ground water levels are high in southwest monsoon followed by summer, winter and northeast monsoon periods. The average annual ground water level of the state is 4.99 meters. The seasonal ground water level fluctuation is low in winter. The ground water recharge is worked out using Radhakrishna et al (1974), U.S Geological Method (1977), Seghal (1970), and Krishna Rao (1970) methods. The average recharge of four methods is about 122.53 mm. The total ground water potential of the state is about 15.901 billion m³ which works to be about 12.42% surface water resources.

Introduction

Ground Water or subsurface water is the water that occurs in the subsurface layers of the earth. The main source of ground water is infiltration. The infiltrated water after meeting the soil moisture deficiency percolates to subsurface layers of the earth and becomes the ground water. The studies on ground water are carried by Sambasiva Rao and Nageswari (1983) and Sambasiva Rao (1983, 1984, 1991 and 2012.)

Sambasiva Rao and Nageswari (1983) has studied the surface and subsurface water resources of the cumbum Water of Madhurai District. Sambasiva Rao (1983) has the land water resources of the Madhurai District, Tamilnadu. The ground water level variations, fluctuations and recharge of the Madhurai District has been described by Sambasiva Rao (1984). The water balance and development of land and water resources of Tamilnadu is studied by Sambasiva Rao (1996). The studies on geographic evolution and development of land, water and watersheds of the Kunderu basin are studied by Sambasiva Rao (2012) using Remote Sensing Data.

Study Area

The Tamilnadu state cover an area of about 1.3 lakh sq.km and lies 8.05' to 13.34 north latitude and 76.10 to 80.20' east longitude in south-eastern part of India. The total population of the State is 72,147,030 (2011 Census). The density of population is 555/km² persons. The state in the north is bordered by Andhra Pradesh, northwest by Karnataka, west and southwest by Kerala and east by Bay of Bengal. The State on an average receives rainfall of about 986 mm. per annum. There are 31 districts, 226 taluks and 385 blocks in the state. The total number of revenue villages are 16,564, hamlets 58,457 and 434 urban centres. The total length of coastline is about 1000 km.

Objectives

The main objectives of the study are:

1. To study the ground water level variations on seasonal and annual basis.
2. To study the ground water level fluctuations on seasonal and annual basis and
3. To work out the ground water recharge and potential of the Tamilnadu State.

Methodology: The monthly ground water level data from the 51 stations has been collected over the period of 10 years. The data is used to work out the seasonal and annual ground water level variations and ground water level fluctuations. The ground water recharge is work out for 51 stations adopting Radhakrishna et al (1974), U.S Geological Method (1977), Seghal (1970), and Krishna Rao (1970) methods. The average of the four methods is taken as annual ground water recharge of the Tamilnadu State. The Ground Water potential of the state is worked out taking average ground water recharge and geographical area of the state.

Ground Water Level Variations in Tamilnadu

The monthly ground water level data for about 500 controlled wells has been collected and averaged to 51 stations over a period of ten years. The seasonal and annual ground water level variations are worked out (Table 4.2). In winter period the maximum ground water level of 7.20 metres is found in Uttampalyam and the minimum ground water level of 1.10 metres is noticed in Vedaranyam. The average ground water level of the state during winter period is 4.16 metres. The spatial distribution shows the ground water level depth gradually increases from east to west. High ground water levels of about 6

Metres are found in Palani – Pollachi and Coimbatore areas. During summer period the minimum ground water level of 2.10 metres is found in Vedaranyam and the maximum ground water level of 8.75 metres is noticed in Uttampalyam. The average ground water level of the stateduring summer is 5.10 metres. The spatial distribution shows a gradual increase in ground water level depths from east to west with more highs around Palani hills. In southwest monsoon period the minimum ground water level of 2.50 metres is found in Vedaranyam and maximum ground water level of 9.50 metres is found in Palani. The average ground water level of the state is 5.82 metres. The spatial distribution shows steeper gradients of ground water level in southeastern part of the state and gentle gradient in northern parts of the state. The ground water depth increased from east to west with highs around Palani hills. During northeast monsoon period the minimum ground water level of 1.90 metres in Thanjavur and the maximum ground water level of 7.80 metres in Uttampalyam are found. The average ground water level of the state is 4.63 metres.

The ground water gradient is steep in southeastern part of the state and gentle in northeastern and central part of the state. The ground water level increases from east to west with high depths around Palani hills. The annual minimum ground water level of 1.92 metres is found in Vedaranyam and the maximum ground water level of 8.29 metres is noticed in Uttampalyam. The average annual ground water level of the state is 4.99 metres. The ground water gradient is steep in southeastern part and gentle in northern parts of the state. The ground water level increases from east to west with highs around Palani hills.

Table 1: Ground Water Level Variations in Tamilnadu State
(All values in mm)

S. No	Station	Winter	Summer	South west Monsoon	North east Monsoon	Annual
1	2	3	4	5	6	7
1.	Ponneri	1.52	2.54	2.84	2.13	2.25
2.	Chennai	1.40	2.60	2.94	2.13	2.25
3.	Chengalapattu	2.40	3.20	3.95	2.80	3.08
4.	Villipuram	3.50	4.10	5.10	3.80	4.12
5.	Cuddalore	1.30	2.40	3.10	2.20	2.25
6.	Thanjavur	1.25	2.20	2.74	1.90	2.01
7.	Nagapatnam	1.25	2.30	2.65	1.95	2.04
8.	Pedukkottai	2.50	2.80	3.20	2.70	2.80
9.	Vedaranyam	1.10	2.10	2.50	2.00	1.92
10.	Ramanad	1.40	2.20	2.80	2.10	2.12
11.	Mudukulattur	2.40	3.20	3.80	2.70	1.21
12.	Tuticorin	1.30	2.10	2.60	2.00	2.00
13.	Tondi	1.15	2.15	2.65	2.00	1.99
14.	Radhapuram	3.85	4.25	4.75	4.10	4.24
15.	Kanyakumari	1.40	2.30	2.70	2.00	2.10
16.	Udagamangalam	-	-	-	-	-
17.	Kodaikanal	-	-	-	-	-
18.	Benecord's Estate	-	-	-	-	-
19.	Hereford;s Estate	-	-	-	-	-
20.	Vellore	3.20	4.34	4.84	4.15	4.20
21.	Tiruttani	3.80	4.85	5.25	4.25	4.54
22.	Tindivanum	4.10	5.15	5.75	4.85	4.96
23.	Vulunderpuri	3.70	4.24	4.80	4.10	4.21
24.	Dharmapuri	5.60	6.50	7.85	5.80	6.44
25.	Hosur	5.70	6.80	7.90	5.75	6.54
26.	Salem	5.60	6.55	7.65	5.35	6.20
27.	Coibatore	6.10	6.80	7.85	6.30	6.76
28.	Bhavani sagar	5.80	6.70	7.70	5.90	5.22
29.	Avanashi	5.85	6.85	7.90	6.10	6.68
30.	Pollachi	6.20	6.90	7.95	6.40	6.86
31.	Karur	4.10	5.25	5.85	4.30	4.87
32.	Tiruchi	3.50	4.45	4.90	4.10	4.24

33.	Nammakal	4.00	4.85	5.25	4.20	4.57
34.	Virdhunagar	4.40	5.60	5.90	4.70	5.15
35.	Mettur	5.30	6.20	6.90	5.50	5.97
36.	Attur	5.40	6.40	7.10	5.70	6.15
37.	Erode	5.70	6.60	7.50	5.90	6.42
38.	Dindigul	5.20	6.35	7.35	5.80	6.25
39.	Palani	7.10	8.70	9.50	7.50	8.20
40.	Vedasandur	6.80	8.10	8.50	7.60	7.75
41.	Uttampalayam	7.20	8.75	9.40	7.80	8.29
42.	Madurai	4.10	4.75	5.70	4.50	4.76
43.	Tirupattur	5.95	6.95	7.85	6.50	6.81
44.	Sivaganga	5.50	6.75	7.65	6.30	6.55
45.	Virudhanagar	5.65	6.65	7.50	6.30	6.55
46.	Nilakkottai	6.50	7.55	8.45	7.20	7.42
47.	Tirunelveli	3.60	4.40	4.90	3.90	4.20
48.	Namgureri	5.10	6.20	7.35	6.10	6.19
49.	Tenkesi	5.60	6.40	7.45	6.20	6.41
50.	Ambasamudram	5.85	6.78	7.50	6.30	6.59
51.	Sattur	5.65	6.40	7.30	5.90	6.31

Ground Water Level Fluctuations in Tamilnadu

The seasonal ground water level fluctuation for winter period (Table 3.3) reveals that the minimum of fluctuation of 0.30 metres is found in Thanjavur station and the maximum fluctuation of 1.70 metres is noticed in Coimbatore. The average winter fluctuation is 0.98 metres. The spatial distribution of winter fluctuation shows that in the coastal region it is about 0.5 metres, and in the western uplands the fluctuation is about 1.5 water. During summer period the fluctuation in ground water level ranges from a minimum of 1.00 metres in Thanjavur, Ramanand and Tuticorinto a maximum of 2.20 metres in Palani and Vedasandur. The average fluctuation of the station is 1.53 metres. The spatial distribution shows that the fluctuation is low and varies from 1.00 to 1.25 metres in coastal plains and 1.5 to 2 metres in western uplands of the state. In southwest monsoon the ground water level fluctuation varies from a minimum of 1.50 metres in Ramanand to a maximum of the state is 2.03 metres. The spatial distribution shows that ground water level fluctuation during southwest monsoon period is less than 2 metres in coastal plains and 2.0 to 3.0 metres in western uplands. During northeast monsoon period the ground water level fluctuation ranges from a minimum of 1.80 metres in Tuticorin to a maximum of 3.20 metres in Coimbatore. The average fluctuation of the state is 2.28 metres. The spatial distribution shows less than 2.5 to 3.0 metres in Palani, Vedasandur and Coimbatore uplands. The annual fluctuation in ground water level varies from a minimum of 2.10 metres in Tuticorin and Thanjavur to a maximum of 3.60 metres in Vedasandur. The annual average fluctuation of the state is 2.68 metres. The spatial distribution shows that the fluctuation varies from 2.0 to 2.5 metres in coastal plains and 2.5 to 3.0 metres in western uplands.

Table 2: Ground Water Level Variations in Tamilnadu State
(All values in mm)

S. No	Station	Winter	Summer	South west Monsoon	North east Monsoon	Annual
1	2	3	4	5	6	7
1.	Ponneri	0.50	1.20	1.75	2.10	2.40
2.	Chennai	0.60	1.20	1.90	2.20	2.80
3.	Chengalapattu	0.65	1.15	1.85	2.25	2.70
4.	Villipuram	0.70	1.25	1.95	2.10	2.50
5.	Cuddalore	0.40	1.10	1.60	1.90	2.00
6.	Thanjavur	0.30	1.00	1.50	2.00	2.10
7.	Nagapatnam	0.55	4.15	1.80	2.10	2.20
8.	Pedukkottai	0.75	1.35	1.95	2.35	2.50
9.	Vedaranyam	0.35	1.10	1.65	1.95	2.15
10.	Ramanad	0.50	1.00	1.50	1.90	2.20
11.	Mudukulattur	0.70	1.25	1.85	2.15	2.40

12.	Tuticorin	0.45	1.00	1.60	1.80	2.10
13.	Tondi	0.50	1.20	1.85	2.20	2.50
14.	Radhapuram	1.10	1.20	1.85	2.20	2.50
15.	Kanyakumari	0.70	1.35	1.65	2.10	2.60
16.	Udagamangalam	-	-	-	-	-
17.	Kodaikanal	-	-	-	-	-
18.	Benecord's Estate	-	-	-	-	-
19.	Hereford;s Estate	-	-	-	-	-
20.	Vellore	0.90	1.40	1.90	2.30	2.70
21.	Tiruttani	1.10	1.60	2.00	2.50	2.80
22.	Tindivanum	0.75	1.30	1.90	2.20	2.60
23.	Vulunderpuri	0.60	1.10	1.65	2.10	2.50
24.	Dharmapuri	1.40	1.70	2.80	2.90	3.10
25.	Hosur	1.50	1.90	2.90	3.00	3.40
26.	Salem	1.10	1.70	2.00	2.40	2.80
27.	Coibatore	1.70	2.10	3.10	3.20	3.50
28.	Bhavani sagar	1.40	1.80	2.70	2.90	3.40
29.	Avanashi	1.30	1.80	2.10	2.30	2.50
30.	Pollachi	1.60	2.00	2.85	3.00	3.50
31.	Karur	1.10	1.60	1.90	2.10	2.50
32.	Tiruchi	0.80	1.30	1.80	2.00	2.40
33.	Nammakal	1.00	1.50	1.70	1.90	2.20
34.	Virdhunagar	0.90	1.45	1.95	2.10	2.40
35.	Mettur	1.10	1.70	2.00	2.20	2.50
36.	Attur	1.20	1.90	2.10	2.30	2.70
37.	Erode	1.30	1.80	1.90	2.10	2.60
38.	Dindigul	1.30	2.10	2.50	2.90	3.40
39.	Palani	1.50	2.20	2.80	3.10	3.50
40.	Vedasandur	1.40	2.20	2.60	3.00	3.60
41.	Uttampalayam	1.50	1.90	2.60	2.90	3.20
42.	Madurai	1.00	1.80	2.10	2.30	2.80
43.	Tirupattur	1.10	1.50	1.80	2.00	2.50
44.	Sivaganga	1.15	1.65	1.95	2.15	2.65
45.	Virudhanagar	1.20	1.60	1.80	2.10	2.70
46.	Nilakkottai	1.00	1.70	2.00	2.10	2.60
47.	Tirunelveli	0.80	1.80	1.70	2.00	2.50
48.	Namgureri	1.20	1.80	2.00	2.20	2.60
49.	Tenkesi	1.10	1.60	1.90	2.10	2.50
50.	Ambasamudram	1.25	1.90	2.15	2.25	2.70
51.	Sattur	1.10	1.70	1.95	2.15	2.80

Ground Water Recharge of Tamilnadu State

Ground water recharge has been worked out based on fluctuation in ground water level and mean rainfall on seasonal and annual basis. It has also been worked out adopting Radhakrishna et al. (1974), U.S. Geological method (1985), Seghal method (1970) and Krishna Rao method (1970). According to Radhakrishna et al. (1974) method the annual recharge for each rain gauge station will be 10% of the annual rainfall. According to this method the annual recharge (Table 3.4) varies from a minimum of 60 mm in Tuticorin station to a maximum of 194 mm in Udagamangalam. The average of the state is 99 mm. According to U.S. geological method. The annual recharge is 15% of the mean annual rainfall. The annual recharge varies from a minimum of 91 mm in Tuticorin station to a maximum of 291 mm in Udagamangalam station. The average of the state is 148 mm. According to Seghal (1970) method the annual recharge is $G=2.5(p-16)0.5$, where P is precipitation in inches. According to this method the minimum annual recharge of 178 mm is found in Tuticorin and the maximum recharge of 493 mm is noticed in Udagamangalam station. The average of the state is 295 mm. According to Krishna rao (1970) method the annual recharge is $G= k(p-x)$, where K is constant, X = annual rainfall and $G=0.2(p-400)$ when annual rainfall range is 400 mm to 600 mm. $G=0.3(p-500)$ when annual rainfall range is 1000 to 2000 mm. According to this method the

annual recharge varies from a minimum of 31 mm in Tuticorin to a maximum of 432 mm in Udagamangalam. The average recharge of the state is 146 mm. From the said method it has been found that seghal's method annual recharge values are very high, followed by Krishna Rao, and U.S. Geological methods. The annual recharge of the four methods of the state is 172 mm. Recharge has also been worked out by specific yield method taking fluctuation in ground water level, mean rainfall and specific yield. According to this method the seasonal recharge values during winter period varies from a minimum of 1.3 mm in Avanashi and Pollachi (Table 3.5) to a maximum of 16.3 mm in Tirunelveli. The average recharge during winter period is 0.55 mm. the spatial distribution shows less than 5 mm in western uplands and 5 to 15 mm in coastal plains. During summer period the recharge values range from a minimum of 7.2 mm in Chennai to a maximum of 47.4 mm in Hereford's estate. The average of the state is 18.78 mm. The spatial distribution shows higher values of 20 mm to 40 mm in hilly terrain and less than 20 mm in plain regions.

**Table 3: Annual Ground Water Recharge In Various Station Ns of Tamilnadu State In Different Months
(All values in mm)**

S No	Station	Radhakrishna Et al Method	u.s Geological Method	Seghal Method	Krishna rao Method
1	2	3	4	5	6
1.	Ponneri	103	154	314	158
2.	Chennai	127	191	371	232
3.	Chengalapattu	121	181	357	213
4.	Villipuram	116	173	345	197
5.	Cuddalore	135	202	376	255
6.	Thanjavur	117	175	347	200
7.	Nagapatnam	137	205	390	260
8.	Pedukkottai	92	138	285	126
9.	Vedaranyam	153	230	423	310
10.	Ramanad	82	123	256	95
11.	Mudukulattur	73	109	227	69
12.	Tuticorin	60	91	178	31
13.	Tondi	98	148	303	145
14.	Radhapuram	73	109	226	68
15.	Kanyakumari	130	195	377	241
16.	Udagamangalam	194	291	493	432
17.	Kodaikanal	164	246	442	342
18.	Benecord's Estate	160	240	435	330
19.	Hereford;s Estate	182	273	473	395
20.	Vellore	97	145	298	141
21.	Tiruttani	101	151	309	152
22.	Tindivanum	118	178	352	205
23.	Vulunderpuri	104	156	318	163
24.	Dharmapuri	71	106	219	63
25.	Hosur	78	118	246	86
26.	Salem	84	126	263	103
27.	Coibatore	71	106	219	63
28.	Bhavani sagar	73	109	226	68
29.	Avanashi	74	111	229	71
30.	Pollachi	88	132	274	114
31.	Karur	65	97	196	50
32.	Tiruchi	84	126	262	103
33.	Nammakal	79	118	246	86
34.	Virdhunagar	109	163	329	176
35.	Mettur	85	128	264	106
36.	Attur	97	146	300	142
37.	Erode	72	108	222	65

38.	Dindigul	84	126	261	101
39.	Palani	73	109	226	68
40.	Vedasandur	72	108	224	67
41.	Uttampalayam	74	112	231	73
42.	Madurai	88	131	273	113
43.	Tirupattur	98	147	302	145
44.	Sivaganga	102	153	312	154
45.	Virudhanagar	82	128	255	95
46.	Nilakkottai	78	117	244	85
47.	Tirunelveli	86	130	269	109
48.	Namgureri	79	109	224	85
49.	Tenkesi	98	147	302	144
50.	Ambasamudram	93	139	287	128
51.	Sattur	72	108	222	65

During southwest monsoon the recharge values varies from a minimum of 3.9 mm in Tuticorin to a maximum of 132.6 mm in Udagamangalam. The average of the state is 39.12 mm. The spatial distribution shows higher values of more than 50 mm in western hilly terrain and less than 50 mm in plain regions. In northeast monsoon period the average varies from 25.9 mm in Vedasandur to a maximum of 128.5 mm in Vedaranyam. The average of the state is 58.08 mm. The spatial distribution shows higher values of 75 mm to 100 mm in central and northern coastal plains and below 75 mm in western uplands. The annual recharge varies from a minimum of 67.3 mm in Vedasandur to a maximum of 242.5 mm in Udagamangalam. The average of the state is 122.53 mm. From the study of

Table 4: Seasonal and Annual Ground Water Recharge Water Recharge In Variuos Stations Of Tamilnadu (All values in mm)

S. No	Station	Winter	Summer	South west Monsoon	North east Monsoon	Annual
1	2	3	4	5	6	7
1.	Ponneri	2.1	8.5	48.1	69.5	128.2
2.	Chennai	7.1	7.2	45.5	99.4	118.2
3.	Chengalapattu	6.8	8.5	49.6	86.4	151.3
4.	Villipuram	7.1	12.1	53.9	71.4	144.5
5.	Cuddalore	11.1	11.5	42.5	103.6	168.7
6.	Thanjavur	10.6	14.3	36.0	85.0	145.9
7.	Nagapatnam	13.5	13.3	27.4	116.8	171.0
8.	Pedukkottai	6.9	15.6	43.3	49.1	114.9
9.	Vedaranyam	16.1	16.5	30.6	128.5	191.7
10.	Ramanad	9.4	13.6	17.0	62.3	102.3
11.	Mudukulattur	7.4	14.5	17.5	51.9	91.3
12.	Tuticorin	7.3	12.1	3.9	52.4	75.3
13.	Tondi	6.5	16.6	49.3	50.8	123.2
14.	Radhapuram	6.0	12.4	17.1	55.5	91.0
15.	Kanyakumari	5.8	39.0	68.3	49.8	162.9
16.	Udagamangalam	8.8	34.5	132.6	66.6	242.5
17.	Kodaikanal	13.4	42.8	68.3	80.6	205.1
18.	Benecord's Estate	12.8	40.0	70.8	76.4	200.0
19.	Hereford;s Estate	6.4	47.4	127.9	45.5	227.2
20.	Vellore	4.9	13.3	55.0	48.1	121.3
21.	Tiruttani	2.0	8.1	58.5	57.3	125.9
22.	Tindivanum	8.6	12.5	49.0	78.0	148.1
23.	Vulunderpuri	7.5	13.5	47.9	61.5	130.4
24.	Dharmapuri	3.9	19.0	22.3	43.6	88.8
25.	Hosur	2.6	22.6	42.0	31.1	98.3
26.	Salem	3.1	19.9	44.4	37.9	105.3

27.	Coibatore	3.9	19.0	22.3	43.6	88.8
28.	Bhavani sagar	2.8	21.5	19.5	47.3	91.1
29.	Avanashi	1.3	22.0	28.	40.9	92.3
30.	Pollachi	1.3	19.1	50.3	39.3	110.0
31.	Karur	2.3	16.3	24.6	37.9	81.1
32.	Tiruchi	5.0	16.8	34.1	49.4	105.3
33.	Nammakal	2.3	20.3	39.4	36.5	98.5
34.	Virdhunagar	7.9	12.6	49.8	65.8	136.1
35.	Mettur	1.8	22.6	43.0	39.5	106.9
36.	Attur	4.8	19.6	49.1	38.04	11.9
37.	Erode	3.3	20.3	26.3	39.5	89.7
38.	Dindigul	5.5	19.3	27.6	52.3	104.7
39.	Palani	5.0	18.4	18.6	48.9	90.9
40.	Vedasandur	5.2	15.2	18.3	25.3	24.5
41.	Uttampalayam	4.9	19.0	21.3	47.9	93.1
42.	Madurai	6.6	21.4	30.3	51.3	109.6
43.	Tirupattur	5.9	17.5	49.0	50.4	122.8
44.	Sivaganga	6.6	17.5	41.3	61.9	127.3
45.	Virudhanagar	7.4	9.8	24.2	25.9	67.3
46.	Nilakkottai	5.5	22.5	26.0	43.6	97.9
47.	Tirunelveli	16.3	17.4	13.6	60.8	108.1
48.	Namgureri	7.3	15.8	14.8	52.8	90.7
49.	Tenkesi	11.1	25.9	22.0	63.6	122.6
50.	Ambasamudram	14.3	19.6	14.6	67.4	115.9
51.	Sattur	6.4	17.5	15.4	50.44	89.7

seasonal recharge it has been found that during southwest and northeast monsoon period the recharge values are high and low in winter and summer periods.

The total ground water potential of the state is estimated to be 15,901,208,000 m³ which works out to be 12.42% of the total surface water resources of the state.

Conclusions

The average annual ground water level variations of the Tamil Nadu State is 4.99 metres. The ground water gradient is steep in the south eastern part and gentle in the northern part of the state. The ground water level variations increase from east to west. The average annual ground water level fluctuation of the state is 2.68 metres. The fluctuation vary from 2.0 to 2.50 metres in Coastal plains and 2.5 to 3.0 metres in westran uplands. The average annual recharge of the Tamil Nadu State is 172mm. The total ground water potential is about 15.90 billion m³

References

1. Radhakrishna,B.P,DUSAN,D, And PALIMQUIST,W.N(1974) Ground water studies,Public No150,of Karnataka, Bangalore.
2. U.S GEOLOGICAL SURVEY (1977),office of water data coordination, National Hand Book of recommended methods for water data acqurisation.Washington D.C
3. SEGHAL, S.R.(1970) International Hydrological news leter, India.No.5,pp.5.
4. KRISHNA RAO,P.R.(1970) Ground Water potential in hard rock areas of India. Publication of Government of Karnataka,Bangalore.