Draft Report

केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report on

AQUIFER MAPPING AND MANAGEMENT PLAN

Bagepalli Taluk, Chikballapur District,Karnataka

दक्षिण पश्चिमी क्षेत्र, बैंगलोर

South Western Region,Bengaluru

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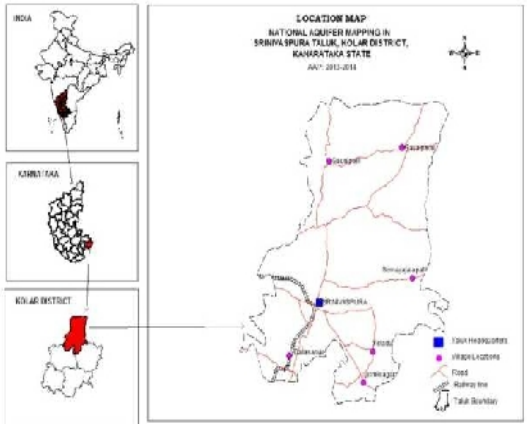
GOVERNMENT OF INDIA

MINISTRY OF WATER RESOURCES,

RIVER DEVLOPMENT AND GANGA REJUVENATION

CENTRAL GROUND WATER BOARD

BAGEPALLI TALUK AQUIFER MAPS AND MANAGEMENT PLANS, CHIKBALLAPUR DISTRICT, KARNATAKA



By

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CENTRAL GROUND WATER BOARD
SOUTH WESTERN REGION
BANGALORE
FEBRUARY 2017

BAGEPALLI TALUK AQUIFER MAPS AND MANAGEMENT PLANS, CHIKBALLAPUR DISTRICT, KARNATAKA

CONTENTS

BAGEPALLI TALUK AQUIFER MAPS AND MANAGEMENT PLANS, CHIKBALLAPUR DISTRICT, KARNATAKA

1.0 SALIENT FEATURES

Taluk name: **BAGEPALLI**

District: Chikballapur;

State: Karnataka

Area: 935 sq.km.

Population: 183498

Annual Normal Rainfall: 653.15 mm

1.1 Aquifer management study area

Aquifer mapping studies under **National Aquifer Mapping (NAQUIM)** were carried out in **Bagepalli taluk**, Chickballapur district, Karnataka state covering an area of **935 sq. kms**. Bagepalli taluk is a part of North Pennar river basin located at longitudes13^{0}37'28": 13^0 57' 32" and east latitude of 77^{0}43'15": 78^{0}07'38" falling in Survey Of India Toposheet numbers 57 G/13, 57 G/14, 57 K/1 & 57K/2. The study area is bounded by Chhilamathur (Andhra Pradesh) in the west, Gudibanda taluk in the south Gorantla taluk (Andhra Pradesh) in the north and towards east Madanapalli (Andhra Pradesh). Location map of the taluk is illustrated in Fig. 1.

Bagepalli is the taluk headquarter with five revenue hoblies - Chelur, Guluru, Kasaba, Mittemari and Patpalya, which covers 212 inhabitated and 17 un-inhabitated villages. The taluk is well connected with good network of roads with NH-7 – Bangalore to Hyderabad passing through the taluk.

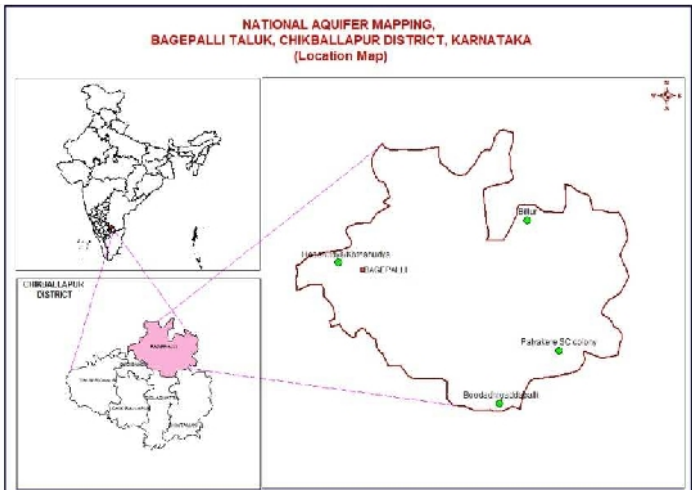

Fig 1: Location Map of Bagepalli taluk, Chickballapur district

1.2 Population

As per 2011 census, the total population in Bagepalli taluk is 183498 (92905 males and 90593 Females), of which 150576 (82%) constitutes the rural population. The study area has an overall population density of 196 persons per sq.km. The decadal population growth rate between 2001 and 2011 is 7.5 %.

1.3 Rainfall

Bagepalli taluk is semi-arid, drought prone, with low, erratic rainfall. It falls under Eastern dry agro-climatic zone of Karnataka state. The climate is quite agreeable and free from extremes. It is hot in summer, highest day temperature is in between 29° C to 37° C. Average temperature of January is 23° C, February is 24 ° C, March is 27° C, April is 29 ° C and May is 30° C.

Rain fall data analysis of Bagepalli for the period 1981 to 2010 (30 years) indicates that 57 % (372.0 mm) of the total rain fall is from south west monsoon, followed by Northeast monsoon with 28 % (182.6 mm) than during free monsoon with 15.10 % (98.6 mm). Overall the annual rain fall of the taluk is 653.15 mm, with mean monthly rainfall ranged between 1.4 mm in January to 146 mm during September. The details of Statistical analysis of rainfall over Bagepalli taluk is in the below Table 1.

Table1: Statistical Analysis of Rainfall data of Bagepalli taluk for the Period 1981 to 2010

parameters	JAN	FEB	MARCH	APRIL	MAY	PRE	JUNE	JULY	AUG	SEP	SW	OCT	NOV	DEC	NE	ANNUAL
NRF (mm)	1.4	3.6	12.7	23.6	57.3	98.6	60.1	82.8	82.6	146.4	372.0	123.6	48.2	10.8	182.6	653.2
CV (%)	535	235	214	91	78	54	90	79	77	49	45	71	88	140	57	32
% of ARF	0.2	0.6	1.9	3.6	8.8	15.1	9.2	12.7	12.7	22.4	57.0	18.9	7.4	1.6	28.0	100.0
Standard deviation	8	9	27	21	44	53	54	65	63	72	167	88	42	15	104	207

Based on variability of annual/monthly/seasonal rainfall as measured in terms of coefficient of variation (Cv) is more than 30 percent, i.e. CV percent in pre monsoon, south west monsoon and Northeast monsoon is 54, 45 & 57 percent respectively, and overall it is 32%, which indicates that the rainfall is said to be erratic and the area is drought prone.

Drought analysis over 50 years (1961 to 2010) indicates that the taluk experienced normal rainfall for 31 years, excess rainfall for 13 years and moderate drought conditions for 6

years. Based on the analysis, the frequency of occurrence of drought is once in 8 years at Bagepalli taluk.

1.4 Agriculture & Irrigation

Bagepalli taluk having 15076 (82%) of rural population is wholly dependent on rain fall for their agricultural activities. Land use pattern of the taluk is presented in the Table 2.

Table 2: Land use pattern in Bagepalli taluk

Geographical area (Ha)	Area under forest (Ha)	Area not available for cultivation (Ha)	Uncultivable land (Ha)	Fallow land (Ha)	Area sown (Ha)		
					Net sown area	Area sown more than once	Total cropped area
90009	18458	14288	11597	37824	29016	7842	36858

District at a glance 2012-2013

1.4.1 Principal crops

Principal crops in the taluk are Maize – 14114 ha (38.29% of the total cropped area) and Groundnut -12010 ha (32.58%). Overall food grains are the major crops comprising cereals and pulses which are grown in an area of 20095 ha (54.52%) during Rabi season. Vegetables and paddy (184 ha) are the Kharif crops. The principal crops and area grown are mentioned in Table 3.

Table 3: Principle crops and area covered under different crops

Crops	Cereals (Ha)			Pulses (Ha)			Fruits (Ha)	Vegetables (Ha)	Oil seeds, (Ha)	
	Maize	Ragi	Others	Tur dal	Avare	Others			Ground nut	others
	14114	2924	302	1890	418	447	1223	1785	12010	257
Total	17340			2755			1223	1785	12267	
	Food Grains						Fruits	Vegetables	Oilseeds	

Source: District at a glance

1.4.2 Irrigation Practices

In Bagepalli taluk ground water is being developed from ground water abstraction structures viz. 380 dug wells and 4345 shallow tube wells (Source: Report on 4th census of Minor Irrigation Schemes 2006 - 2007) for irrigation purpose. Ground water developed from these structures are managed through water distribution irrigation practices by adopting - Open channel (2347 bore wells & 316 dug wells), Underground pipe (1927 bore wells & 25 dug wells), surface pipe (26 bore wells &10 dug wells), drip irrigation (3 bore wells) sprinklers and others (42 bore wells &4 dug wells).

1.4.3 Ground water and surface water Irrigation

The main source of irrigation in Bagepalli taluk is ground water only. The net irrigated area during 2013-2014 was 4794 ha against the gross irrigated area of 5642 ha. There is no surface

water irrigation since there are no major/medium irrigation projects. There are 515 tanks, which are not available for irrigation, since there is no sufficient filling/storage, which can cope with irrigation. There is growth in the number of ground water structures with reference to 2012 - 2013 to 2013 – 2014, instead there is decrease in gross and net irrigated area from 7842 ha and 6288 ha to 5642 ha and 4794 ha respectively.

1.5 Geomorphology, Physiography & Drainage

Geomorphologically Bagepalli taluk is covered with uplands on Gneisses and Granites. Physiographic features are of southern maidan region, characterized by undulating landscape with broad valleys, and an average elevation of 707 m to 1116 m amsl. Bagepalli taluk is the part of North Pennar river basin with Chitravathy and Papagani as its tributaries originating in the hills south west of Chickballapur. These tributaries are ephemeral in nature and flows during monsoon season only. The general drainage pattern is of sub-rectangular due to marked influence of geologic structures in the basin figure 2.

1.6 Geology

Bagepalli taluk is situated on the Archean Peninsular Gneissic Complex comprising the oldest formation of archean age with Granites and Gneiss as major rock formation figure 3.

1.7 Soil

Soils of the area are derived from Granites/Gneiss, which is of red soil group in the form of clayey with mixed or skeletal of loamy skeletal. During hydrogeological surveys soil infiltration tests were conducted and the details of sites, initial infiltration rates, and final infiltration rates, cumulative depth of infiltration and duration of test are given in the Table 4.

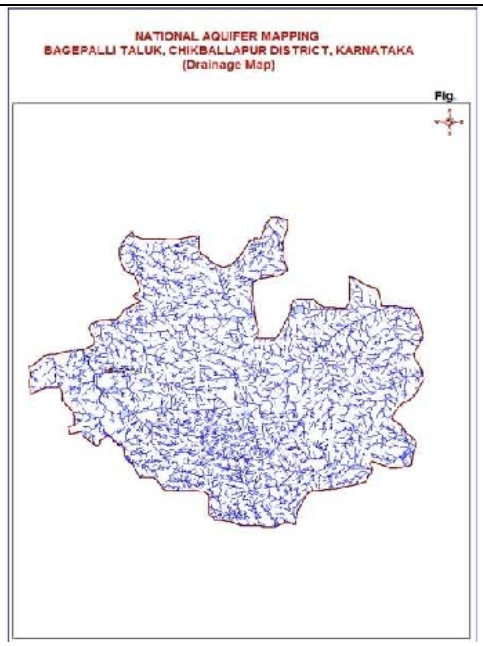

Fig 2: Drainage map

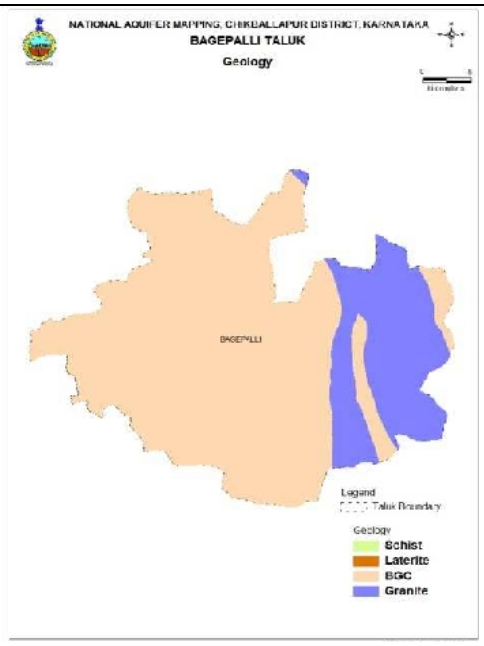

Fig. 3: Geology map

Table 4: Soil infiltration test results

Sl.No.	Site name	Initial infiltration rate (cm/hr)	Final infiltration rate (cm/hr)	Cumulative depth of infiltration (cm)	Test duration in minutes
1	Gurraladinne	30.0	2.40	12.70	140
2	Patpalya	54.0	2.40	14.95	160
3	Raidurganahalli	15.0	0.15	5.30	180
4	Palcheruvu	30.0	4.95	25.80	160
5	Thimmampalli	42.0	4.50	16.90	160
6	Achaganapalli	60.0	4.50	26.65	160
7	Mittemari	6.0	1.80	10.10	160

1.8 Ground water resource availability and extraction

As per ground water estimation 2011, in Bagepalli taluk, Total GW Resource availability is 9879 ham, of which Annual Replenishable ground water resource is 6552 ham and fresh in storage ground water resources fractured up to the depth of 200 m is 3327ham. Considering fresh in storage ground water resources fractured up to the depth of 450 m the Total GW Resource availability works out to be 14170 ham, of which Dynamic ground water resources is 6552 ham and fractured ground water resources is 7618 ham**.** As per the estimation (GEC 2011) ground water draft (extraction) for irrigation is worked out to be 5681.82 ham.

1.9 Existing and future water demands

As per the GEC (2011), existing ground water resources (draft) for irrigation, industrial & domestic is 5965.99 ham and for future with judicious utilization, since the stage of ground water development has already reached up to 91 %. It is 1878.95 ham, of which 313.74 ham is for domestic & industrial use, and 1565.21 ham is for future irrigation purposes.

1.10 Water level behavior

In Bagepalli taluk the dug wells indicating phreatic aquifers (Aquifer – I) are dry up to the depth of 20.00 m. However, the pre-monsoon depth to water levels in bore wells (Aquifer II) ranged from 6.62 m to 78.50 m bgl with an average of 31.28 m Fig. 4. The post-monsoon depth water levels in Aquifer II ranged from 0.10m to 75.04 m, with an average of 17.16 m Fig.5. Annual ground water fluctuation ranged from 2.76 m to 48.71 m, with an average of 14.30 m, Fig. 6 and water table elevation map pre-monsoon is given in Fig. 7 & post-monsoon is in Fig. 8.

During post-monsoon, micro level hydrogeological survey and well inventory was done over Bagepalli taluk, and data reveals that overall depth to water level observed to be from 1.83 mbgl to 160.35 mbgl and depth of casing ranged from 1.20 m to 27.00 m. Based on depth of casing the weathered thickness has been analyzed and presented in Fig. 9.

The analysis of long term water level trend in Aquifer-I indicates falling trend of 0.134 m/y during pre-monsoon and 0.374 m/y during post-monsoon with overall falling trend of 0.092 m/y. Similarly in Aquifer-II rising trend of 1.662 m/y during pre-monsoon and 0.069 m/y during post-monsoon with overall raising trend of 0.862 m/y.

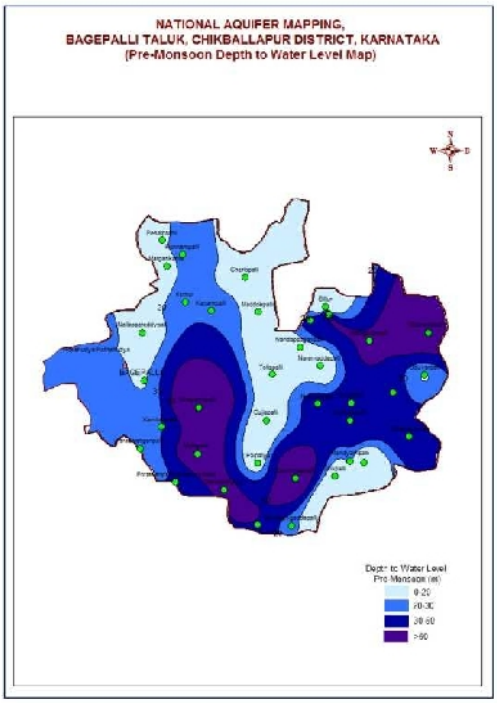

Fig. 4: Pre- monsoon DTW Map

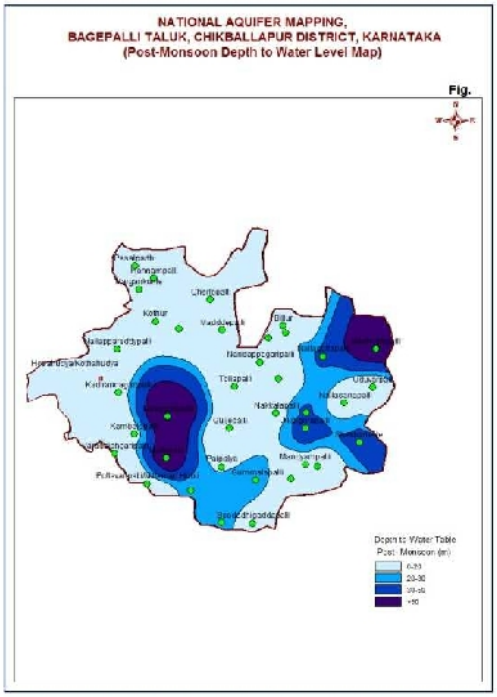

Fig. 5: Post-monsoon DTW map

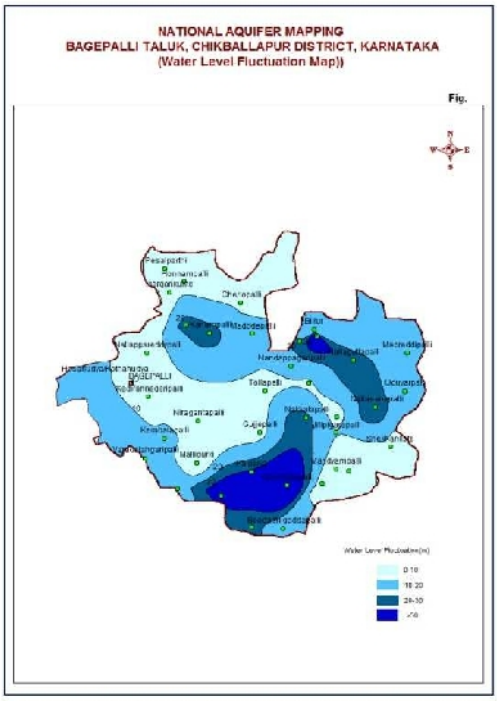

Fig. 6: Water level fluctuation map

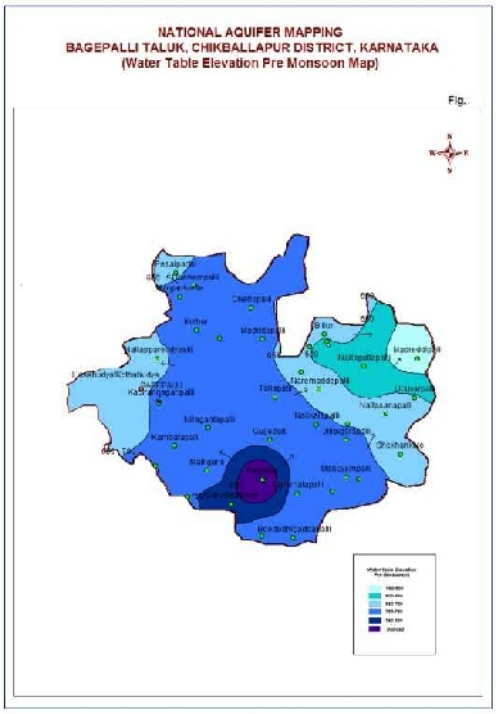

Fig. 7: Pre-monsoon Elevation map

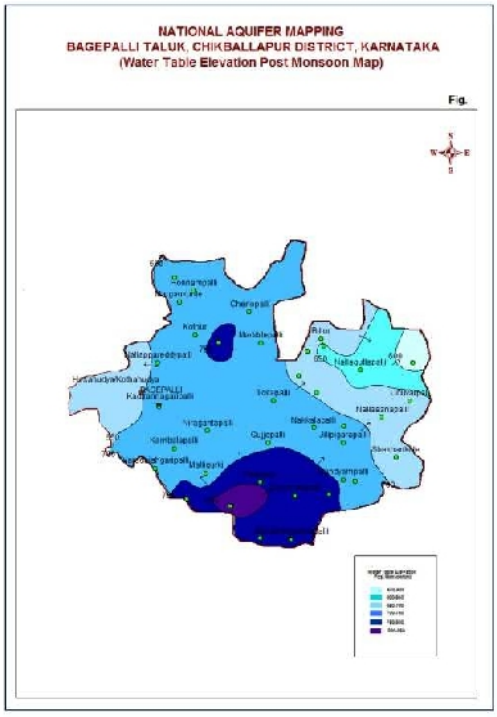

Fig. 8: Post-monsoon Elevation map

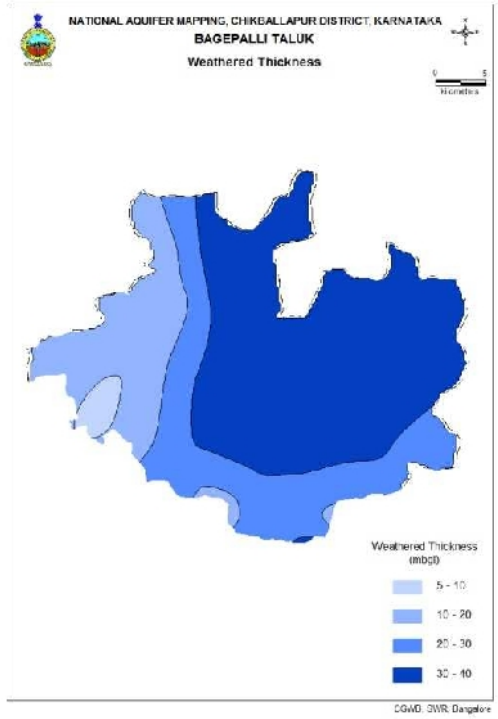

Fig. 9: Weathered thickness map

2. AQUIFER DISPOSITION

The study of aquifer disposition is helpful in effective management of delineated aquifers in an area. Intensive hydrogelogical surveys, Geophysical investigation, collection of groundwater samples for determining quality of ground water and ground water exploration were carried out in Bagepalli taluk as part of NAQUIM. The analysis of these data, mainly the data pertaining to Geology (Lithologs), weathering depth (casing depth), fractures encountered at different depth range with the rate of discharge and aquifer parameters etc., which are collected during ground water exploration (Table 5), were made use to delineate the aquifer system, geometry, which in turn is helpful in understanding aquifer capacity, since the domain of ground water management depends on the quantification of ground water / aquifer, and to determine the extension of aquifer in terms of both lateral and vertical extent is referred as aquifer disposition.

Aquifer parameter/Transmissivity of Aquifer-I over Bagepalli taluk were determined through slug tests as detailed in Table 6. Transmissivity values thus determined over the taluk varies from 3.1 to 41 m^2/day with an average of 17.97 m^2/day.

Table 5: Details of Ground water Exploration

Sl. No	EW/OW site	Toposheet No	Coordinates	Depth drilled, m	Thickness of weathering, m	Depth of casing in m bgl	Fractures encountered (m)		Aquifer	Static Water level (m)	Discharge In LPM	D.D. (m) In 120 minutes	T m2/day
							From	To					
1	Bagepalli Karlakunte	57 G/13	13047'27.1" 77047'43.9"	300.10	19.00	19.70	12.10 208.00	13.00 210.00	Granite	131.95	26.58	-	-
2	Paragodu	57 G/14	13044'11.5" 77047'33.0"	348.90	19.50	22.30	196.00	197.00	Granite	29.73	24.00	-	4.40
3	Giriyapalli	57 G/14	13041'11.6" 77050'46.5"	300.10	29.00	29.50	82.50 112.90 153.00	84.00 114.00 155.00	Granite /gr. gneiss	61.00	35.52	-	-
4	Bodikadirepalli	57 G/14	13040'34.1" 77056'10.9"	300.10	20.50	21.30	168.00 259.00 283.00	171.00 260.00 285.00	Granite	74.35	200.40	-	-
5	Billur EW	57 K/1	13051'24.7" 78000'06.0"	205.50	11.00	11.80	90.00 127.00 139.00 192.00	92.00 129.00 140.00 194.00	Granite	65.46	607.20	-	-
6	Billur OW	57 K/1	$13^0$51'24.7" $78^0$00'06.0"	219.00	11.00	11.60	17.00 123.00 143.00 188.00 214.00	19.00 125.00 145.00 190.00 216.00	Granite	52.84	607.20	0.73	83.71
7	Chelur	57 K/2	$13^0$42'14.1" $78^0$05'51.5"	329.50	24.50	25.20	21.00 29.00 120.00	23.00 31.00 123.00	Granite	5.15	107.34	56.52	1.345
8	Digavapyayalavaripalli	57 K/1	$13^0$48'15.7" $78^0$05'25.8"	214.50	18.00	18.80	59.00 135.00	62.00 137.00	Granite /gr. gneiss	18.03	107.34	51.13	0.583
9	Thimmampalli	57 G/13	$13^0$51'12.6" $77^0$55'11.5"	245.50	14.50	15.20	27.00 57.90 120.90 173.80	29.00 59.00 123.00 175.00	Granite	14.15	862.80	6.86	102.43
10	Gortipalli EW	57 G/13	$13^0$55'21.4" $77^0$57'23.9"	165.70	17.00	18.00	86.40 131.00	92.50 133.10	Granite	10.38	622.28	9.28	9.58
11	Gortipalli OW	57 G/13	$13^0$55'21.4" $77^0$57'23.9"	282.00	16.50	17.40	24.30 88.40 127.00	25.40 90.40 129.00	Granite	4.17	250.20	43.23	0.715
12	Range			165.70 to 348.90	11.00 to 29.00	11.60 to 29.50	12.10	285.00		4.17 to 131.95	24.00 to 862.80	0.73 to 56.52	0.583 to 102.43

Table 6: Details of slug test and results of transmissivity

Sl. No.	Name of the village	Depth of the bore well, m	Depth of casing, m	Diameter of the well, m	SWL, mbgl	Volume of the slug injected (N) in (m^3)	Test duration, seconds	Transmi-ssvity m^2/Day
1	Boodadhigaddapalli	90.00	6.00	0.1524	3.22	0.02	600	24
2	Palyakere	300.00	16.00	0.1651	35.58	0.02	960	11
3	Chelur	225.00	12.00	0.1524	7.33	0.02	600	41
4	Venkatapura	90.00	10.50	0.1524	4.36	0.02	600	30
5	Meruvapalli	300.00	12.00	0.1651	16.34	0.02	1320	5.8
6	Nagarlu	165.00	9.00	0.1524	11.00	0.02	1200	8.1
7	Errapentla	200.00	8.00	0.2032	3.43	0.02	900	27
8	Pyayalavaripalli	180.00	12.00	0.1524	3.27	0.02	900	19
9	Margankunte	240.00	12.00	0.1651	2.29	0.02	2100	7.7
10	Kanampalli	150.00	12.00	0.1524	4.81	0.02	900	26
11	Thimmampalli	90.00	24.00	0.1524	16.44	0.02	1200	13
12	Billur	90.00	18.00	0.1524	7.81	0.02	1200	3.1

2.1 Number of aquifers

Based on the Ground water exploration data In Bagepalli taluk, there are mainly two types of aquifer systems;

i. **Aquifer-I- (Phreatic aquifer)** comprising Weathered Gneiss / Granite ,which is dry.
ii. **Aquifer-II- (Fractured multi-aquifer system)** comprising Fractured Gneiss / Granite

2.2 3 D aquifer disposition and basic characteristics of each aquifer

The Exploration drilling data utilised for generating aquifer disposition maps through Rock works soft ware.

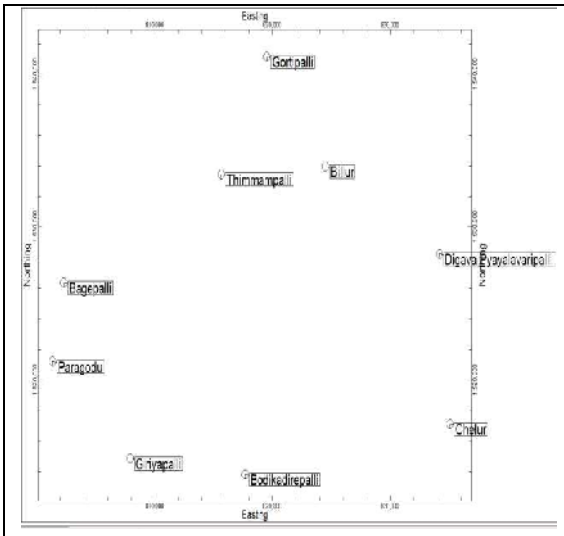

Fig. 10: A Location map

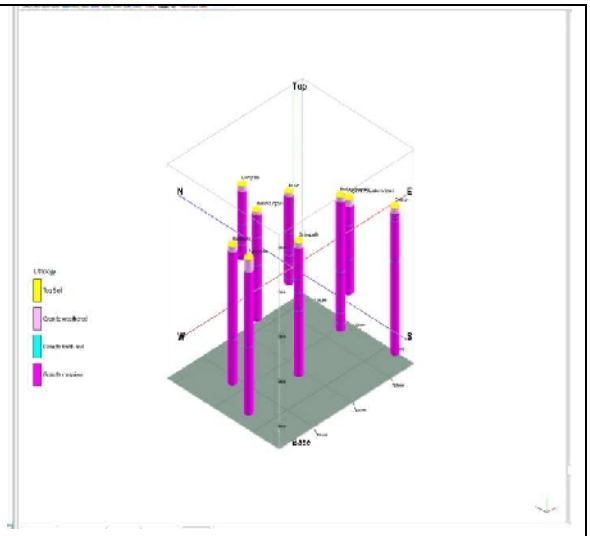

Fig. 10 B: Log Diagram

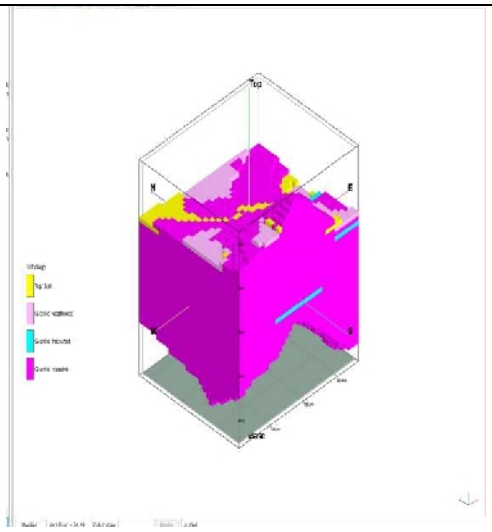

Fig. 11: 3 D Diagram of Aquifers

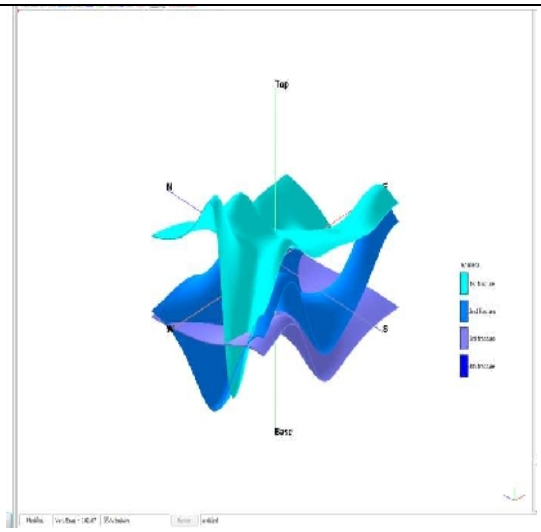

Fig. 12: 3D Aquifer model

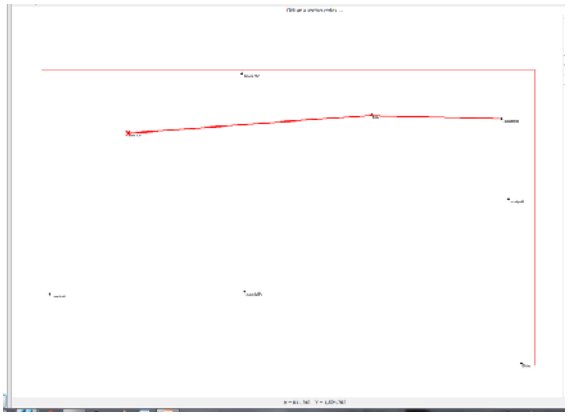

Fig. 13A: Data Location 3 D Diagram, Cross section East-West

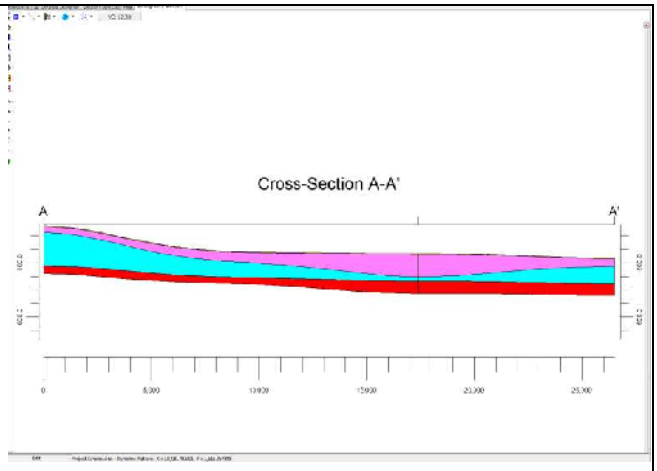

Fig. 13B: Aquifer disposition 3 D Diagram, Cross section East-West

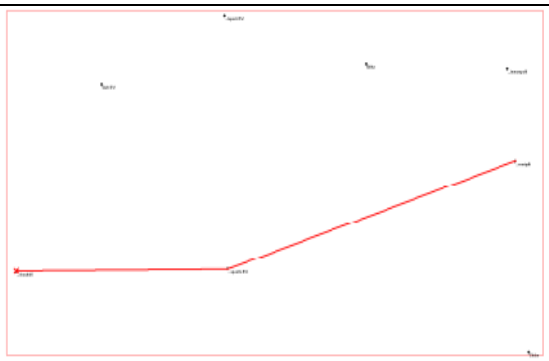

Fig. 14 A: Data location
Cross section East - West

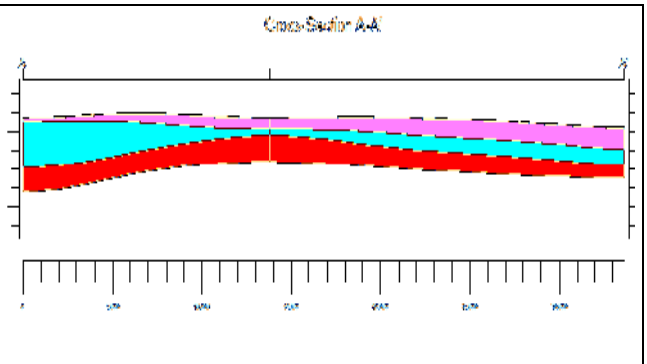

Fig. 14 B: Aquifer disposition, 3 D Diagram
Cross section East - West

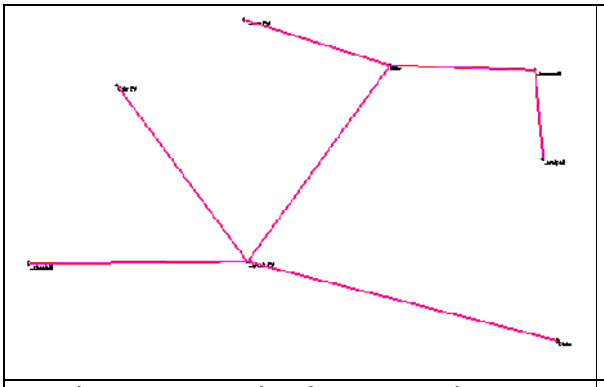

Fig. 15 A: Location for Fence Diagram

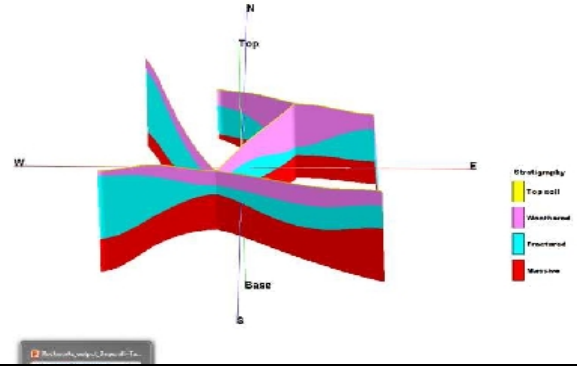

Fig. 15 B: Aquifer disposition – Fence Diagram

3. GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION

3.1 Aquifer wise resource availability and extraction

Aquifer wise ground water resource (2011) has already been discussed above in 1.8 & 1.9. However, overall Groundwater Resource Estimation in Bagepalli taluk as on 2011 & 2013, indicating present and future scenario (2025), Stage of ground water development and categorization is presented in Table 7.

Table 7: Ground Water Resource

Sl. No.	Resource details	As per 2011 Estimation	As per 2013 Estimation
1	Net Ground Water Availability in HAM	6552.03	6568.24
2	Existing Gross Ground Water Draft for Irrigation in HAM	5681.82	5795.46
3	Existing Gross Ground Water Draft for Domestic and Industrial Water Supply in HAM	284.16	426.84
4	Existing Gross Ground Water Draft for all use in HAM	5965.99	6222.30
5	Allocation for Domestic And Industrial Use for next 25 years in HAM	313.74	522.80
6	Net Ground Water Availability for future Irrigation Development in HAM	1565.21	1388.69
7	Existing Stage Of Ground Water Development in percentage	91	95
8	Categorization	**Critical**	**Critical**

3.2 Chemical quality of ground water and contamination

During NAQUIM field surveys 39 number of ground water samples were collected, of which 35 were from bore wells and 4 from dug wells, in Bagepalli taluk. The results thus obtained were analyzed for variation range and average, are presented in Table 8.

Table 8: Variation range and average of chemical constituents in ground water.

Chemical consitituents, PPM	pH	EC in µ /mhos /cm at 25 ^{0} C	Total hardness as $CaCO_3$	Ca	Mg	Na	K	HCO_3	Cl	SO_3	NO_3	F	B	PO_4
Aquifer- I (Dug wells)														
Range	72 to 7.6	880 to 1150	190 to 300	12 to 56	39 to 51	82 to 167	0.9 to 4.9	323 to 354	64 to 149	48 to 68	9 to 45	1.16 to 1.9	1.0 to 1.7	0.11 to 0.17
Average	7.5	1025	240	25	43.1	120	2.15	326	110	58	20.7	1.66	1.4	0.14
Aquifer- II (Bore wells)														
Range	6.8 to 8.0	350 to 2270	70 to 600	8.0 to 44	5.0 to 123	40 to 320	0.73 to 68.6	128 to 576	21 to 476	18 to 186	7 to 95	1.08 to 3.27	0.6 to 2.7	0.14 to 0.51
Average	7.5	1189.7	290.9	21.0	57.6	135.1	4.7	341	144.6	75.4	24.9	1.9	1.8	0.2

3.2.1 Suitability of ground water for drinking purposes

Table 9: Distribution of chemical constituents as per drinking water specification

Sl. No.	Chemical constituents	Limit/class	Required standard as per Indian Standard Specification	Aquifer - I		Aquifer-II	
				No. of samples falling in the category	%	No. of samples falling in the category	%
1	pH	Desirable	6.5 to 8.50	All Samples	100	All samples	100
		Permissible	-	-	-	-	-
		Beyond permissible	-	-	-	-	-
2	Total hardness as$CaCo_3$ In ppm	Desirable	< 300	All Samples	100	24	68.57
		Permissible	301 to 600	-	-	11	31.43
		Beyond permissible	> 600	-	-	Nil	-
3	Ca In ppm	Desirable	< 70	All Samples	100	35 All samples	100
		Permissible	71 to 200	-	-	-	-
		Beyond permissible	> 200	-	-	-	-
4	Mg In ppm	Desirable	>50	3	75	14	40
		Permissible	51 to 150	1	25	20	57
		Beyond permissible	>150	-	-	1	3
5	Cl In ppm	Desirable	<250	All Samples	100	29	83
		Permissible	251 to 1000	-	-	6	17
		Beyond permissible	>1000	-	-	-	-
6	No_3 In ppm	Desirable	<45	All Samples	100	31	88.6
		Permissible	46 to 100	-	-	4	11.4
		Beyond permissible	>100	-	-	-	-
7	So_3 In ppm	Desirable	<200			35(All samples)	100
		Permissible	201 to 400			-	-
		Beyond permissible	>400			-	-
8	F In ppm	Desirable	<1.0			Nil	0
		Permissible	1.0 to 1.5			8	22.85
		Beyond permissible	>1.5			27	65.71

Suitability of ground water for drinking purpose is assessed as per Indian Standard Drinking Water Specification (IS 10500:1991) as detailed in the Table 9, which indicates water is potable and all the required chemical constituents is within the desirable/permissible limits. The distribution of major chemical constituents like Chloride and Nitrate are presented in the Fig. 16 & 17 respectively.

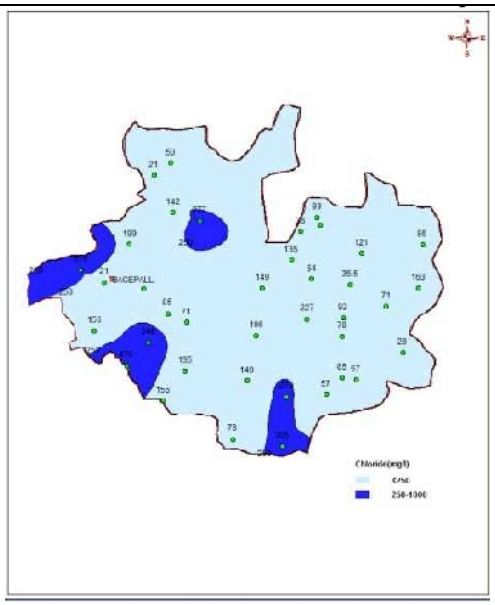

Fig. 16: Chloride distribution

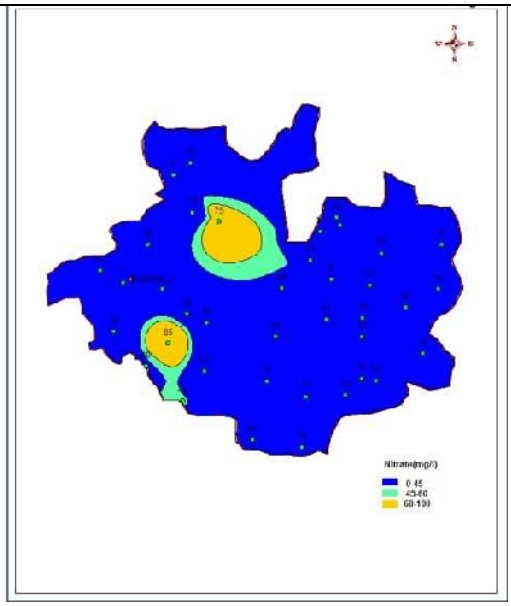

Fig. 17: Nitrate distribution

3.2.2. Classification of ground water for irrigation

Similarly, the utilisation of ground water for irrigation purposes was assessed based on Electric Conductance, Chloride, and Sodium content in the form of percent Sodium and Sodium Absorption Ratio and Residual Sodium Carbonate content. Accordingly, the classification of ground water into different class is presented in Table10.

Table 10: Classification of ground water in to different classes

Sl. No.	Chemical parameter	Class	Limits/Required standard	No. of samples falling in the category	%	Remarks
1	EC in Micro mhos/cm at 25^0C (after wilcox)	Excellent	< 250	-	-	90 % percent of the area falls in excellent to permissbilbe class of ground water for irrigation purposes.
		Good	250 to 750	6	17.14	
		Permissible	750 to 2000	25	71.42	
		Doubtful	2000 to 3000	4	11.42	
2	Chloride (after Scofield)	I	< 700	35	100	Ground water is class I for irrigation purposes
		II	700 to 2000	-	-	
		III	> 2000	-	-	
3	Percent Sodium (after Wilcox)	Excellent	< 20	Nil	-	Ground water is over the area is good to permissible class and good for irrigation
		Good	20 to 40	4	11.42	
		Permissible	40 to 60	31	88.58	

		Doubtful	60 to 80	-	-	purpooses.
4	Sodium Absorption Ratio	Excellent	< 10	35	100	Low Sodium type of ground water over the area and excellent for irrigation purposes
		Good	10 to 18	-	-	
		Fair	18 to 26	-	-	
		Poor	> 26	-	-	
5	Residual Sodium Corbonate	I	< 1.25	31	88.58	Low to medium chloride content falling in Class I & II snf good for irrigation use.
		II	1.25 to 2.00	4	11.42	
		III	> 2.00	-	-	
6	Boran (after Wilcox)	Excellent	>1.00	5	14.28	Most of the area falls in good to permissble class suitable for sensitive to tolerent crops
		Good	1.00 to 2.00	20	57.14	
		Permissible	2.00 to 3.00	10	28.57	

Based on the above chemical data/classification the distribution of chemical constituents like EC, percent sodium, residual sodium carbonate in Bagepalli taluk is presented in Fig. 18, 19 & 20.

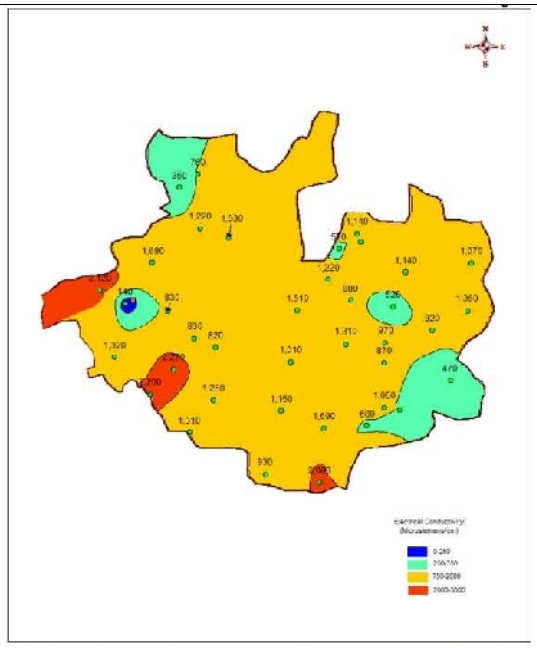

Fig. 18: Distribution of EC

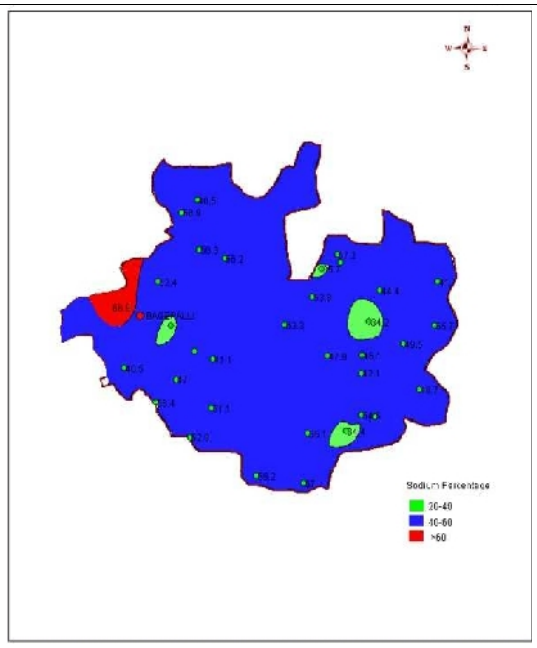

Fig. 19: Distribution of percent Sodium

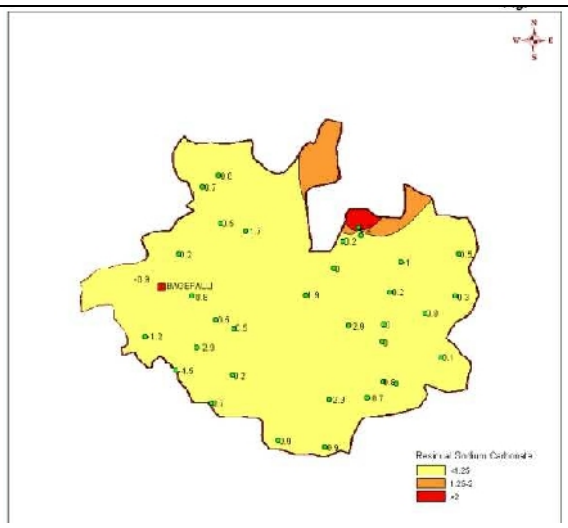

Fig. 20: Distribution of Residual Sodium Carbonate

3.3 Ground water contamination

Fluoride is the major ground water contamination for drinking purpooses in entire Bagepalli taluk. This is quite an intriguing situation as Aq-I is almost dried up and Aq-II is facing quality problem. About 83% of the samples collected are with Fluoride beyond 1.5 ppm, details are in Tables 8 & 9 and distribution is presented in Fig. 21.

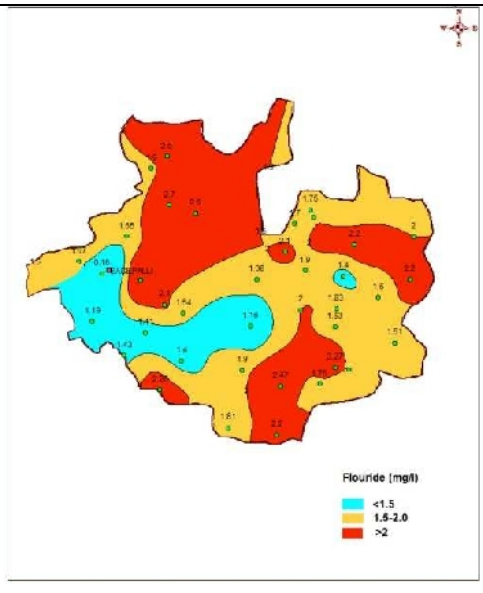

Fig 21. Distribution of Fluoride

4. GROUND WATER RESOURCE ENHANCEMENT

Continuous drought, increase in agricultural activity, subjected to excessive ground water withdrawal, thus leading to depletion of ground water table, reduction in yield and deterioration of ground water quality etc. This suggests a need for proper ground water management for enhancement of storage capacity of aquifers, protection of ground water quality and proper utilization of ground water.

To enhance the storage capacity of aquifers, the dewatered aquifers are to be recharged, for which artificial recharge structures like check dams, percolation tanks, point recharge structures etc. have to be constructed.

4.1 Aquifer wise space available for recharge and proposed interventions

4.1.1 Quantity of water available through non - committed surface run off

The surplus non-committed water from annual rainfall is calculated to be 1320 HAM this can be used to recharge the aquifer through suitable recharge structure, which augments the net ground water availability in the taluk. The details of types of structure/number for recharge structures are presented in the Table 11.

Table 11: Artificial Recharge Structures available/Proposed

Artificial Recharge Structures available/Proposed	Bagepalli tluk
Non committed monsoon runoff available (Ham)	1320
Number of Check Dams	81
Number of Percolation Tanks	6
Number of Point Recharge structures	9
Tentative total cost of the project (Rs. in lakhs)	318.25
Excepted recharge (HAM	796
Expected rise in water level (m)	0.5
Cost Benefit Ratio (Rupees/ cu.m. of water harvested)	3.99

The area suitable for the construction artificial recharge structures in Bagepalli taluk is presented in the Fig. 22.

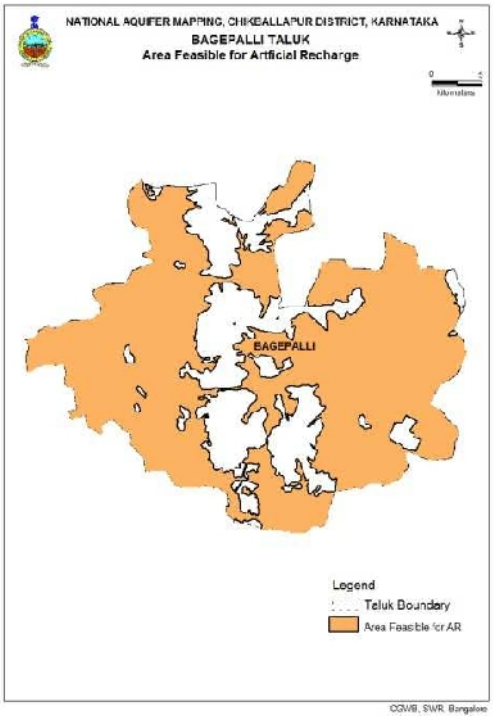

Fig. 22: Area suitable for artificial recharge structures

4.1.2 Proposed Yettinahole project

Yettinahole water project is a flagship project of Karnataka Government that intends to divert water from the west-flowing Nethravathi River to the drought-prone districts, which includes Bagepalli taluk of Chickballapur district. The project proposal comprises two components namely, Drinking water and tank filling. On implementation of this project it will helps to recharge 646 HAM of water to ground water, by which there will be increase in the ground water availability and stage of ground water development.

4.1.3 Urban Tertiary Treated Water

The another scheme of Government Of Karnataka is to replenish tanks of Bagepalli taluk with the treated sewage water from Bangalore city lakes, through which 338 HAM water is expected to recharge ground water in the taluk.

Thus considering above three source water for ground water recharge, the volume of water expected to be conserved or in the ground water resource enhancement is detailed in Table 12.

Table 12: Ground water resource enhancement

Sl. No.	Resource details	As per 2013 Estimation
1	Net Ground Water Availability in HAM	6568.24
2	Existing Gross Ground Water Draft for All use HAM	6222.30
3	Existing Stage Of Ground Water Development in percentage	95
4	Expected recharge from Artificial Recharge Projects HAM	796
5	Additional potential from Proposed Yettinahole Project HAM	646
6	Proposed Tertiary Treated Waste Water of Bangalore City HAM	338
7	Cumulative ground water Availability HAM	8348.24
8	Expected improvement in stage of ground water Development after implementation of the project in percentage	20.47
9	Expected improvement in overall Stage of Ground water development	74.53

5. DEMAND SIDE INTERVENTIONS

5.1 Advanced irrigation practices

Major crops of Bagepalli taluk is Maize, Ragi and Ground nuts, which are rain fed crops. Remaining crops like some of the pulses, vegetables and fruits depend upon the ground water source.

The ground water for irrigation is being developed through 380 irrigation dug wells and 4345 irrigation bore wells. The existing advance irrigation practices and the irrigation potential created in the taluk is mentioned Table 13.

Table 13: Details of Irrigation practices

Sl. No.	Advanced Irrigation practices	No. of Irrigation Dug wells and potential utilized area in hectares		No. of Irrigation Bore wells and potential utilized area in hectares		Total	
		No. Dug wells	potential utilized (area in hectares)	No. of Bore wells	potential utilized (area in hectares)	Total no of structures	Total potential utilised
1	Open water channel	316	123	2347	3449	2663	3572
2	Underground pipe	25	44	1927	3508	1952	3552
3	Surface pipe	10	7	26	46	36	53
4	Drip irrigation	0	0	3	4	3	4
5	Sprinklers	1	0	0	0	1	0
6	Others	28	3	42	30	70	33
	Total	**380**	**177**	**4345**	**7037**	**4725**	**7214**

Source: 4th Census of Minor Irrigation schemes, Department of Minor irrigation, Bangalore, March 2011

On perusal of the above Table 13, the irrigation practices like Drip irrigation & sprinklers as water distribution system is almost nil (4 nos.) with no/negligible irrigation potential utilized

when compared to other distribution systems, resulting in difficulty in maximum water conservation. If these methods of drip and sprinkler irrigation systems increased, maximum available ground water can be conserved. This ultimately enhances the area under irrigation potential.

5.2 Change in cropping pattern

An adverse land - person ratio creates a strong demand for cultivable land, since almost half of the geographical area of the taluk is covered either with forest, land not available for cultivation, hills and rocky fields. Remaining cropped lands are irrigated by an age old network of rain-fed tanks (small lakes), each irrigating 2 to 10 hectares of wet land. The low water table is tapped through bore-wells drilled to more than 100 meters depth. Even these dry up in the summer months. The average rainfall is around 650 mm a year and this is, moreover, erratic and spatial. As a result there is only one rain-fed crop a year. Groundnuts and maize are the main crops grown on these dry lands. The other crops like vegetables & pulses are the common bore-well irrigated crops.

Hence, farmers are facing inadequacy of groundwater for agriculture, and in the taluk about 70% of the farmers have to change in cropping pattern and adopt water economy irrigation practices like drip irrigation and sprinkler irrigation, which are negligible in numberin the taluk. Heavy water consuming crops like paddy and sugarcane are grown in less than 0.63% of the net sown area. If, the remaining 30% farmers also adopt the water use efficient irrigation practices like mulching-plastic sheeting, spread on the ground around plants to prevent excessive evaporation or erosion, enrich the soil, etc., and there will be additional saving in water. Therefore, encouragement from government is essential for achieving full target of water use efficiency in the district.

5.3 Alternate water sources

As per the resource estimation – 2013, Bagepalli taluk falls under **critical category** with 95% stage of development, thus leading towards water scarcity problem. So there is need to formulate management strategy to tackle the water source scarcity in the taluk. It is proposed to achieve this problem of water source scarcity through the following management options:

1.Surplus non committed monsoon runoff water available - through artificial recharge structures.
2. Proposed Yettinahole Project – Govt. Of Karnataka
3. Urban tertian treated water – Govt. Of Karnataka

The above three options are the proposed alternate water sources, through which cumulatively 1780 HAM of water (Table 12) is expected to be conserved.

5.4 Regulation and control

Considering the current existing ground water draft for all use - 6222.30 HAM with the stage of ground water development up to 95%, which is categorized as **critical,** it is necessary to plan augmentation of ground water through artificial recharge, which is mandatory besides use of ground water judiciously.

Due to this grim situation of ground water resources in the taluk /district, state government has planned to conduct an intensive survey of ground water level and its quality and planning to impose a ban on sinking of new irrigation bore wells as per the provisions of the Karnataka Ground Water (Regulation and control of Development and Management) bill 2011.

Apart from this it is mandatory to adopt advanced irrigation practices like drip irrigation, sprinklers and other practices which are reported to be in negligible number and management of ground water for irrigation with water use efficiency methods.

5.5 Other Interventions proposed

Fluorosis, is a crippling disease over entire Bagepalli taluk. People become affected with Fluorosis when they consume high fluoride content water i.e. more than 1.5 mg/l. The high levels of Fluoride content and the toxicity of fluoride is influenced by high ambient temperature, alkalinity, calcium and magnesium contents in ground water pose serious health hazards to humans and irreversible damage to plants.

During the present study from 39 ground water samples which are with noticeable levels of fluoride (Table 8). To mitigate this critical issue of safe drinking water and control Fluorosis, construction of rain water harvesting units at the family level are must. The Govt. Of Karnataka along with number of NGOs (Arghyam Foundation) has already taken up the program of Roof Top Rain Water harvesting in the taluk.

This program of roof top rain water harvesting, direct aquifer recharge, excavation of farm ponds, bore well recharge and timely water quality analysis etc will reduce the Fluoride level in water. Roof top rain water harvesting has been innovative, which were designed for individual households and includes underground storage tank & surface storage tank in front of the houses, and direct connection with the tap has helped to store water without contamination while bringing relief to people suffering from Fluorosis.

Removal of fluoride is also achieved through adoption of standard filtration/ removal techniques like, Reverse Osmosis filtration, Activated alumina de-fluoridation filter and distillation filtration, which is strongly recommended. Other methods like Nalgonda techniques, Ion exchange process, and adsorption methods like activated carbon, Tri calcium phosphate and activated alumina may be used. The blue print for cost effectiveness, economically feasible

techniques with zero environmental impact and inbuilt arrangement for proper sanitary disposal of sludge needs to be prepared.

6. CONCLUSIONS AND RECOMMENDATIONS

NAQUIM studies over an area of 935 sq.kms in Bagepalli taluk, Chikballapur district, are underlain by Granites/Gneiss. It receives annual rainfall of 653.15 mm with drought once in 8 years. The net sown area is 29016 ha against the total cropped area of 36858 ha. The principle crops grown are maize and ground nuts, which are rain fed crops. It is observed that no advance groundwater management practices like sprinkler/drip irrigation or water use efficiency like mulching is being practiced in the taluk.

The average depth to water level during pre-monsoon is 31.28 mbgl and in post-monsoon it is 17.16 mbgl with an average ground water fluctuation of 14.30 m.

The total annual Dynamic ground water resource (2013) is 6568.24 ham with annual ground water draft for all use is 9795 ham. The stage of groundwater development is 95% and categorized as **'Critical'**. Additional resource enhancement of 1780 ham is proposed by available water sources like non committed surface runoff, Yettinahole project and Urban Tertiary Water Treatment.

The abnormal level of Fluoride in water is observed over entire area of Bagepalli taluk, thus, causing health hazard (Fluorosis), which can be tackled through Defluoridation plants and rain water harvesting methods as discussed.