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Brief Hydrogeological Studies of Watershed MR-03 (3/7) in Context of Groundwater Estimation, Washi, Osmanabad, Maharashtra, India

Megha Shinde (Daga)[1] , Chandrakant P. Bhoyar[2] , Ramesh C. Gudepu[3]
[1]Assistant Geologist, GSDA, Osmanabad, Maharashtra,
[2]Senior Geologist, GSDA, Survey Section, Pune, Maharashtra
[3]Assistant Geophysicist, GSDA, Nagpur region, Maharashtra

***Abstract*:- The global population is increasing rapidly and expected to touch the 9.5 billion mark by 2050 from the current 7.2 billion. The management of the groundwater resources is a challenging task worldwide against the backdrop of the growing water demand for industrial, agricultural, and domestic uses and shrinking resources. Moreover, this task has been hampered significantly due to declining/rising groundwater levels and associated contamination. A broad range of solutions could be considered to address the aforementioned problems of groundwater management strategy. This paper presents a comprehensive review on the Water level, Rainfall, Groundwater estimation and cropping pattern of the studied area which can be useful for applications of the management of groundwater resources and recharge techniques.**

It would also be necessary to plan and control the use of groundwater under the prevailing conditions. Publication and distribution of annual reports and related programmes for creating awareness amongst the community and for educating them will have to be undertaken regularly. This will enable avoiding scarcity, as well as the hectic activity and excessive expenditure that has become characteristic of summer months. The present study discussed about the optimum planning of GW recharge and need to control the irrigation draft less than the recharge. Application of Regulatory measures for not drilling bore wells. Optimum use of water saving practices. There should be annual GW budgeting on regular basis, need to plan cropping as per GW availability.

I. INTRODUCTION

Groundwater is a natural resource with both ecological and economic value and is of vital importance for sustaining life, health and integrity of ecosystems. This resource is increasingly threatened by over-extraction which has insidious long-term effects. Scarcity and misuse of groundwater pose a serious threat to sustainable development and livelihood. The availability of groundwater is extremely uneven, both in space, time and depth and so will be the case in future. The uneven distribution of groundwater in the district can be mainly attributed to highly heterogeneous lithology and regional variation of rainfall. Because of variations in their basic characteristics; physiography and variability in the rainfall, there are limitations on the availability of groundwater. Though there is unanimity about this, there is still considerable difference of opinion among the scientists about the precise degree of these limitations. In order to assess the availability of groundwater and to ensure maximum accuracy in groundwater estimates, the Central Government and state government has, from time to time, appointed committees comprising groundwater experts and Geoscientist and has laid down guidelines for this purpose. The total demand for water from the groundwater domain is increasing day by day. The main reason for this is the self reliance being experienced by users of groundwater. But as this is leading to inexorable withdrawal, and as the status regarding total availability of groundwater is of uncertain nature, it is imperative to give more serious thought and a new direction to groundwater planning and management.

Groundwater is the most important natural resources. It provides drinking water to rural as well as urban community, supports irrigation & industry, sustains the flow of streams & rivers and maintains wetland ecosystem. There is significant freshwater deficit in many areas of the State. Human health, welfare and food security are at risk unless the groundwater resources are managed more effectively and efficiently by the community. It is very much obvious that over extraction of ground water over years without any compensatory replenishment is affecting large tracts of land adversely. The non-replenishment of the shallow aquifers and depletion of the deeper aquifers on account of unregulated sinking of deep borewells/tubewells, almost amounting to “water-mining” unmindful of the adverse ecological effects is one of the contributory causes for recurring droughts. Concerted action, therefore, is needed to reverse the present trend of periodic occurrence of droughts.

II. BACKGROUND

The watershed **MR-07 (3/7)** in Washi Taluka of Osmanabad district is one of the study areas identified for to enhance the climate-resilience and profitability of smallholder farming systems in project area in Nanaji Deshmukh Krushi Sanjeevani Prakalp, Mumbai and to frame groundwater recharge plan for the study area. Groundwater being the main source of irrigation in the area for providing protective irrigation during dry spells of rainy season and for rabbi and perennial crops also, the study of groundwater system, its behavior, recharge and withdrawal, and possibilities of groundwater recharge is undertaken in this study area.

The watershed named **MR-07 (3/7)** consists of three villages namely, **Bavi, Sonarwadi and Mandva** having census number 561273,561275 and 561274 respectively. The study area is located in quadrant B-3 and B-1 of the Toposheet no. 47 N/14 and 47 N/15 with latitudes extending from N18^0 30' 41.20" to N18^0 52' 11.33" and longitudes extending from 75^0 52' 37.28" E to 75^0 89' 46.67"E. The area is included in mini watershed no **MR-07 (3/7).** As per the Groundwater Resource Estimation (GWRE) 2016-17, the watershed is categorized as Safe with Stage of extraction 69.16% resp.

There are 03 villages in the Study area, named Bavi,Sonarwadi and Mandva, washi Taluka. Total area of all included villages (in Ha) is 4605, Total Cultivable area of the study area (in Ha) is 4145, Total population(Human) of the Study area 7453, No. of Households in the Study area is 6654, No. of Land Holder in the Study area- 2732, Average land holding size per house hold of the Study area to 2 Ha, Total no. of Dug wells-269 Bore wells-393 Farm ponds-60 in study area. Total cattle population of the study area-6939, Dairy, Goat farming, Poultry Agriculture allied business, No.of drinking water supply sources in all villages, Dug Well-04, Hand Pump-10, PWS-DW-02, PWS-BW- 02. All of three villages are depended on Groundwater for drinking water supply. Total Domestic water requirement for Human (7453 × 365× 60 lpcd) as per GEC 2015 is 0.447/Day TCM, and 163.22/ Annum in TCM. On the other hand, total Domestic water requirement for Cattle is (6939 × 365 × 30 lpcd) is 0.208/day in TCM, and 75.98/ Annum in TCM.Total Domestic water requirement for 3 villages are 0.655/ day in TCM and 239.2/ Annum in TCM. Bavi faced drinking water scarcity in the month of June -2019 to Oct-2019, total Tankers was 504 and Sonarvadi in the month May -2019 to Oct-2019,total Tankers was 271. Total water supplied by Tankers is approx. 7.750 TCM**.** Groundwater draft for domestic purposes (year 2018-19) excluding Tanker water is 231.45 TCM.

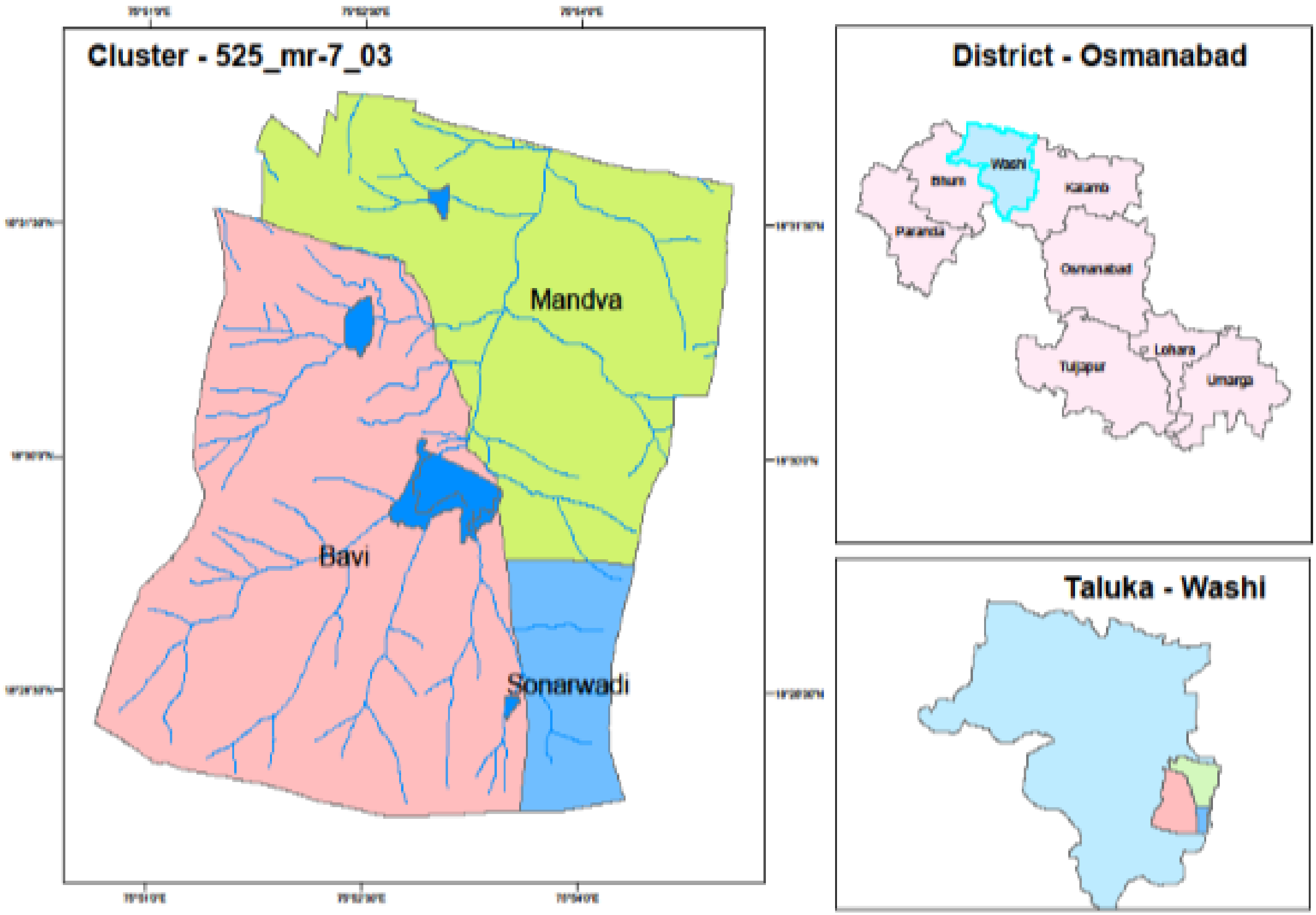


Fig.1 Location Map of the of Study area no **MR-7_03**, Osmanabad

III. METHODS AND METHODOLOGY

In order to study the areaBaseline data collected from different state government department. The detail hydrogeological field survey has been carried out in the month of May-Sept 2019, ,Geophysical (Electrical Resistivity) Survey has been carried out from experts of the organization. Collection and testing of water samples from pipe water supply scheme of studies area was done in the district water testing laboratory of Osmanabad GSDA, Aquifer based Groundwater Estimation is done in the said paper.

Table.1 Statues of Existing Water Conservation Structures

Sr. No.	Name of structure	No.	Total storage capacity in TCM	No. of Fillings	Total annual run off arrested (annual storage) in TCM
1	Cement Nala Bandhara	8	32	2	64
2	Percolation Tank	2	40	1	40
3	Nala Deepening (7200 x 6 x 1) cum	7.2 Km	43	2	86
4	Storage Tank	1	350	1	350
5	Recharge Shaft	5	2.5	2	5.0
	Total	17	467.5		545

There are total 60 farm ponds existed in the study area. Most of the farm ponds are reported to be constructed during the last 3-4 years. Out of these farm ponds 30 (50%) are located along the bank of streams flowing through the study area and remaining 30 (50%) farm ponds are located in inside land away from the streams (Fig.-02).

It is reported that farm ponds located along the stream bank (50%) are filled partially by pumping runoff water accumulated or drained through the streams during the rainy season and partially by groundwater pumped either from dug well or bore well; while the remaining 50% are filled by groundwater pumped either from dug well or bore well, as there is no scope of that much run off to be generated and accumulated in the field. Thus the farm ponds are mainly filled by groundwater which may be pumped either from dug well or bore well. Total storage capacity of these farm ponds is 142.5 TCM. These farm ponds are filled and refilled as per the availability of water and irrigation timings of the crops. Groundwater pumped from dug well or bore well is stored in farm pond and then supplied to the crop either by gravity flow or by pumping.

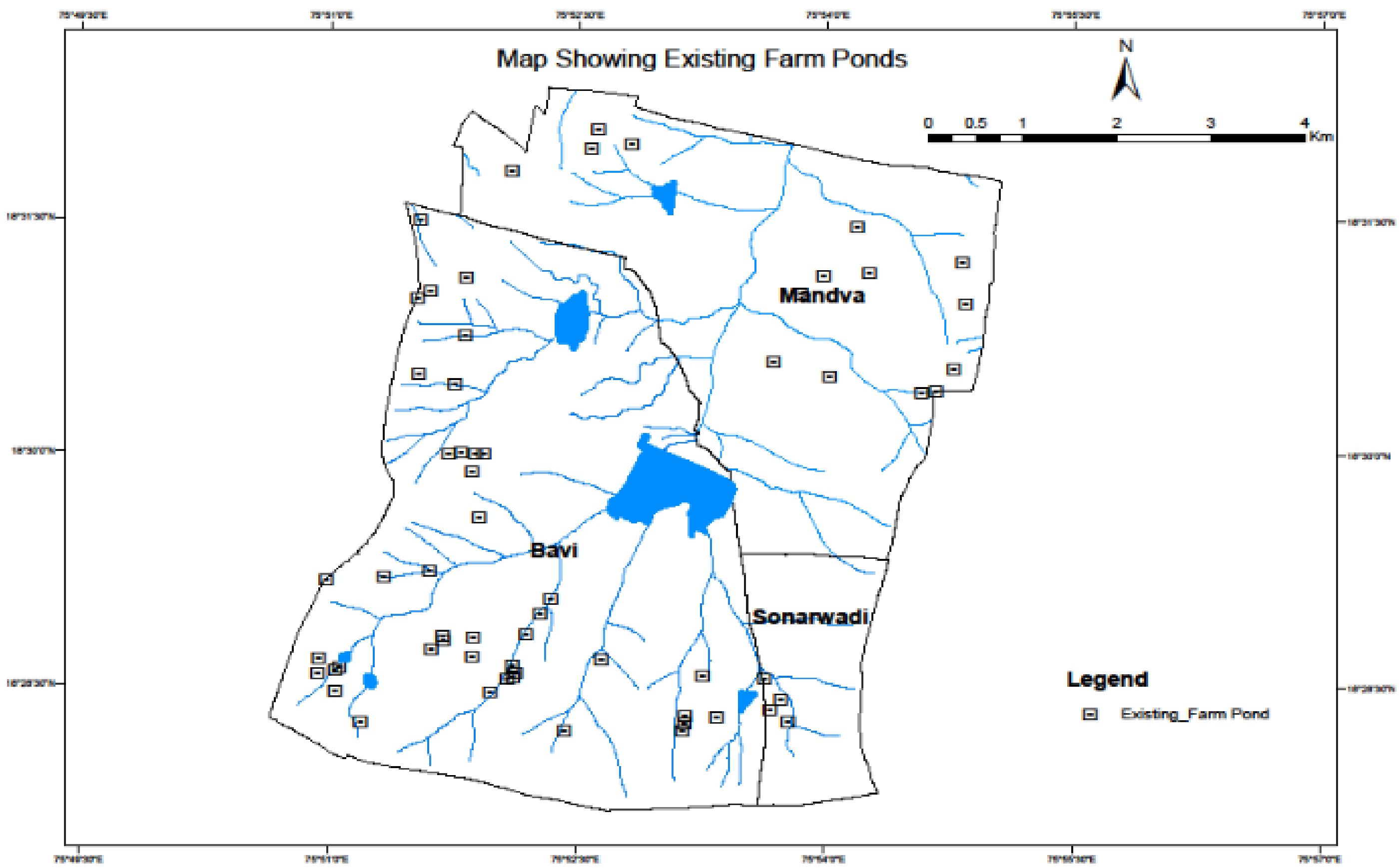


Fig.2 Location Map of farm ponds in the Study area no **525_MR-7_03**, Osmanabad

➢ *Hydrogeological Data Analysis: (Historical Data Analysis and Field Survey):*

Name of nearest is rain gauge station is in ***Terkheda*** Circle of Washi,***Taluka where*** Normal Rainfall is 764mm, Monsoon RF for ***Taluka*** station in year(2018-19) is 463 mm, 75% dependable rainfall for ***Taluka*** station is 520 mm, Monsoon RF for ***Circle*** station in (2018-19) is 458 mm ,Rainy days in (2018-19) for ***Circle*** station is 25.Long term monsoon rainfall over the area is very much fluctuating and shows DPAP signatures although the normal annual rainfall is nearly 764 mm. Long term monsoon rainfall shows falling trend (@2.827 mm/year) for the station (Fig.-03).

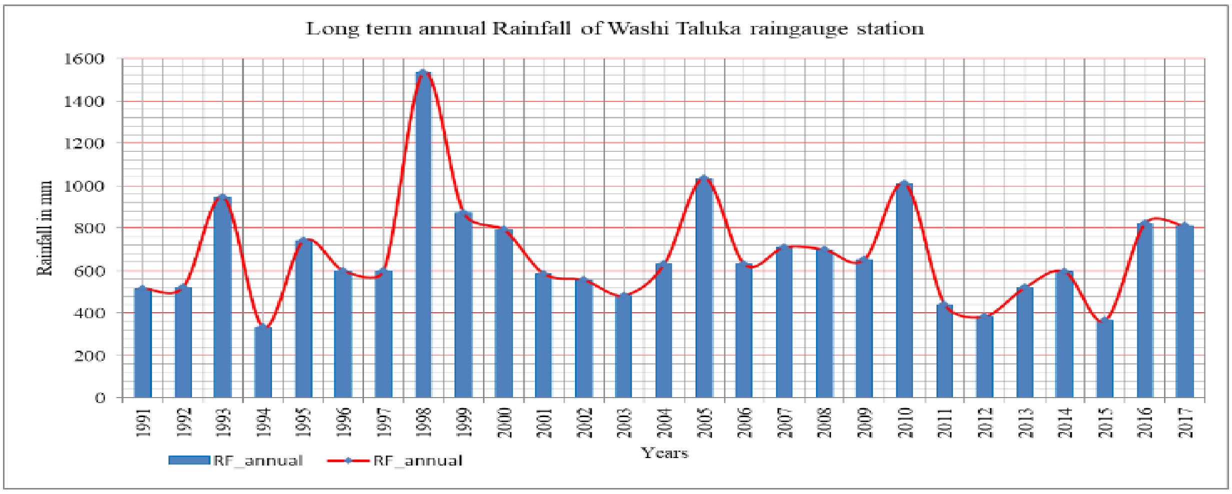
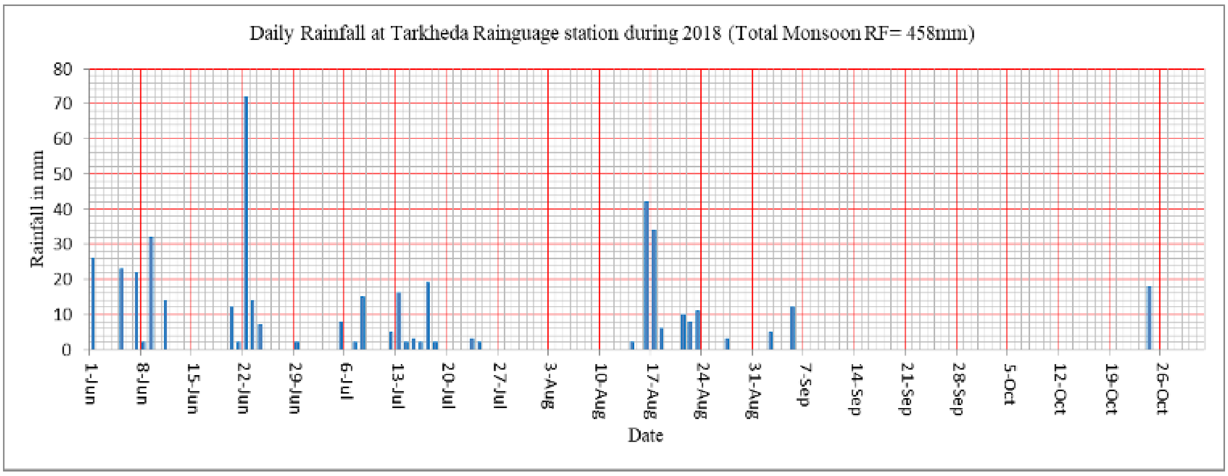
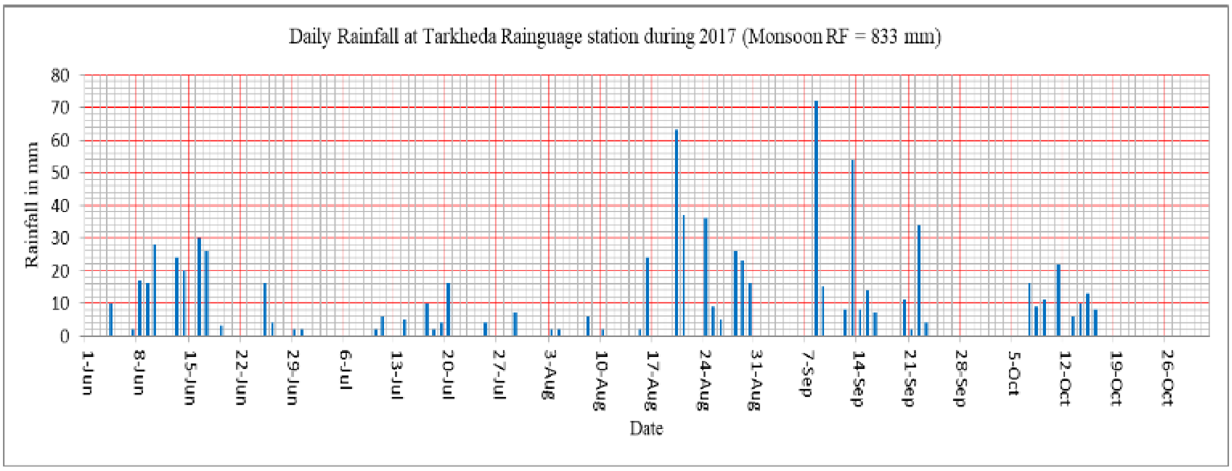


Fig.3 Long term monsoonrainfall of Washi rain gauge station

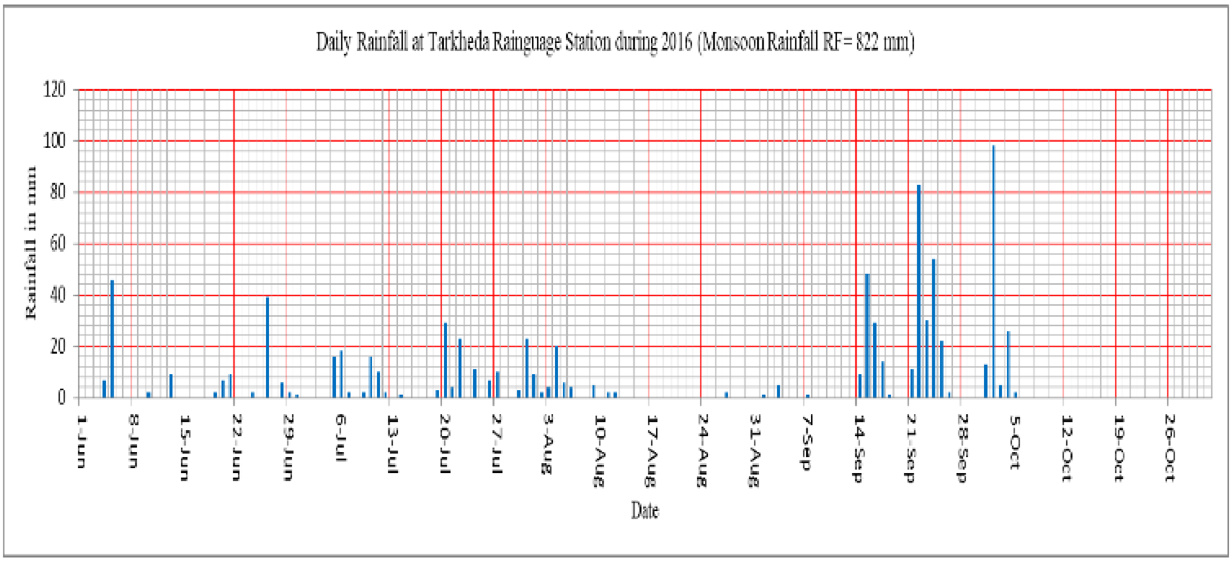
➢ *Analyses of Daily Rainfall Data For Tarkheda Circle:*



A.



B.



C.
Fig.4 A,B,C- Dailyrainfall of Tarkheda circle rain gauge station

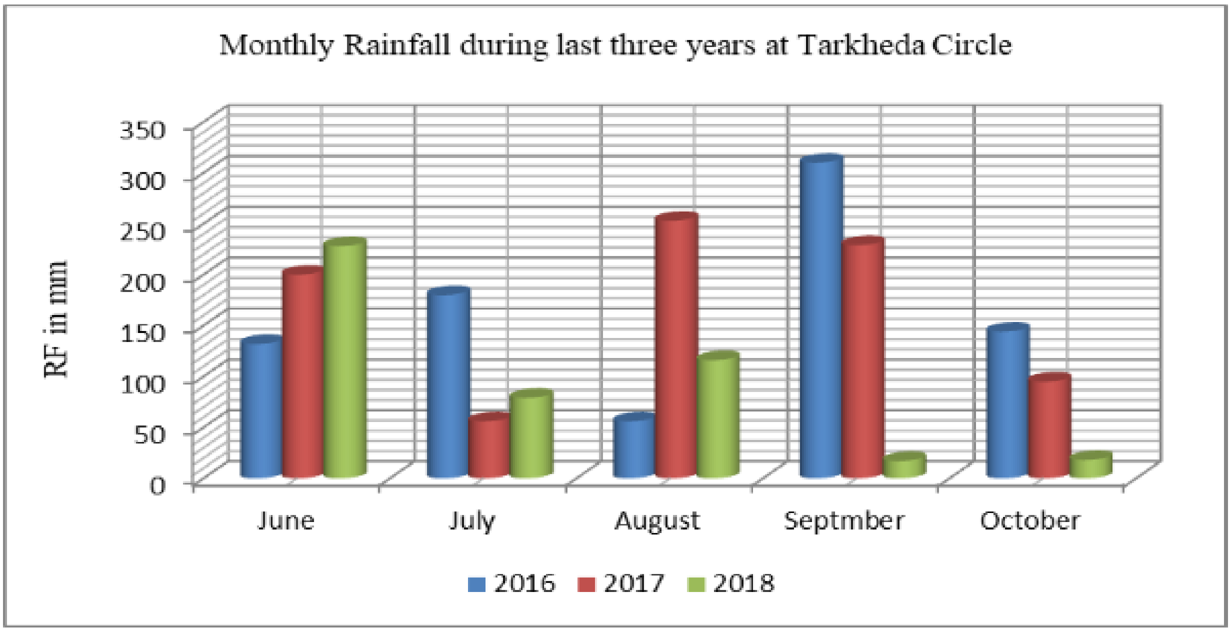


Fig.5 Monthly rainfall at Terkheda circle rain gauge station for last three year

Table.2 Yearwise Rainfall Analysis

Yerawise Rainfall Distribution Analysis			
	2018	**2017**	**2016**
Rainfall (June to October)in mm	458	833	822
Rainy Days (June to October)	35	56	58
Total Days (June to October)	153	153	153
% Rainy Days	45.9	85.68	88.74
Rainy Days <10mm	19	30	37
Rainy Days 10-20mm	9	12	8
Rainy Days 20-30mm	3	8	7
Rainy Days 30-40mm	2	3	1
Rainy Days 40-50mm	1	0	2
Rainy Days >50mm	1	3	3
Total	**35**	**56**	**58**

Run off for the study area is estimated by using run off coefficient obtained from Strange's table. The area is covered by black cotton soil(up to 0.30 to 0.50 mbgl) followed by highly weathered basalt up to 2 to 3 m bgl, with slope percent ranging from 0.50 to 2 % (gentle), thus as per Strange's categorization it comes under category of average catchment from run off point of view. As the annual rainfall is very fluctuating 75% dependable rainfall (return period of 1.32 years) which is the most reliable rainfall value, is considered for estimating the run off.

Normal rainfall for the area is 764 mm which has dependability of 30%, while 75 % dependable rainfall for the area is 520 mm. As per the Strange's table run- off coefficient for average catchment with rainfall of 520 mm is 12% (0.12). Thus if WCS are planned by using this value, the probability of filling of all the structures will be more. Estimated value of run-off is as;

Table.3 Run Off Estimation

RUN OFF ESTIMATION		
1	Total catchment area (Cluster area) in Ha	4605.00
2	Aquifer area in Ha	4605.00
3	non aquifer area in Ha	0.00
4	Average annual rainfall in mm	763.70
5	75% dependable rainfall in mm	519.70
6	Average slope of area in %	0.5 to 2
7	Run off coefficient for the area in %	0.12
8	Run off yield from the area in TCM	2871.86
9	Utilizable Run off for harvesting in TCM = 65% of Row 8 (35% left as riparian rights of the downstream)	1866.71
10	Run off booked for existing WCS structures in TCM	683.00
11	Run off ultimately available for harvesting (9-10)	1183.71
12	No. of fillings assumed	2.00
13	Approximate water storage capacity that can additionaly be created (50% of 11)	591.86

If the annual rainfall is more than the considered value with uniform temporal distribution, as in the case of year 2016 and 2017 the runoff coefficient will be more i.e. 20 % for 780 to 800 mm. So the run off will naturally be more, but dependability of such rainfall and hence the run off is very less.

➢ *Long Term Groundwater Level Trend Analysis (Fig 6 A&B):*

Nearby Observation well (OBW) to the area is Massa Kh, which is located due south-west of the area at a distance of 12 Kms. Long term pre monsoon (summer) groundwater level shows the ***falling*** trend (@ 7.97cm/year) in the area, whereas post monsoon (winter) groundwater level shows the ***rising*** trend (@ 4.1 cm/year) in the area. This indicates that total groundwater recharge occurred by all means during the rainy season is being extracted during the non-monsoon season for all purposes; the main purpose is the irrigation.

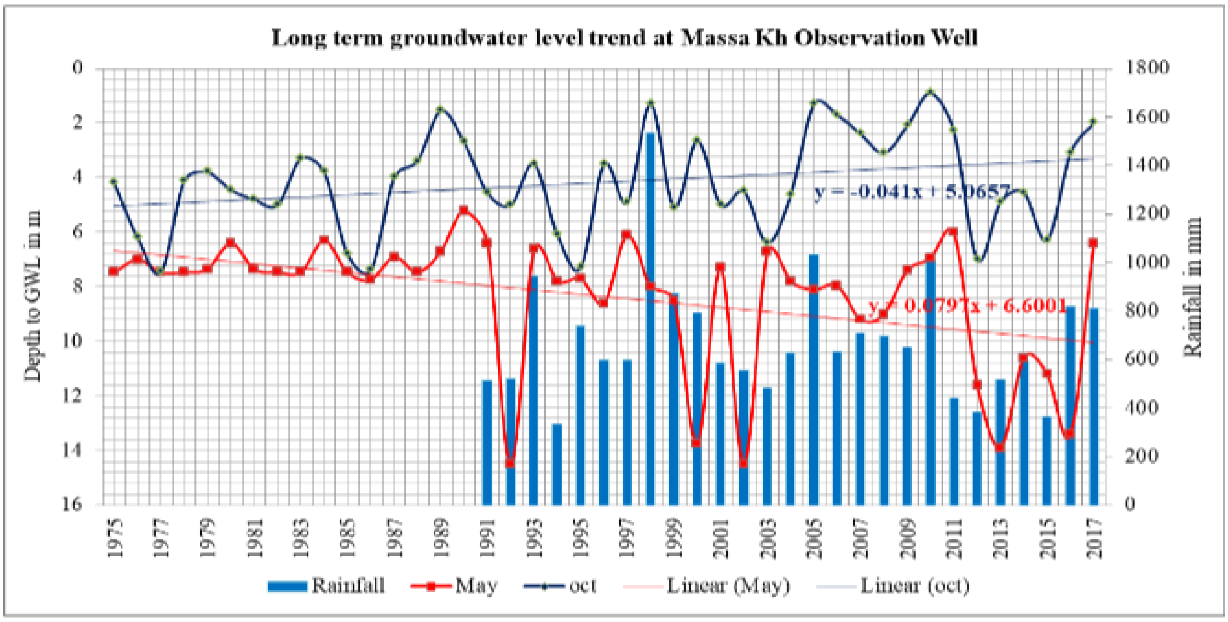


Fig.6 Long term groundwater level trend of Massa Kh. OBW

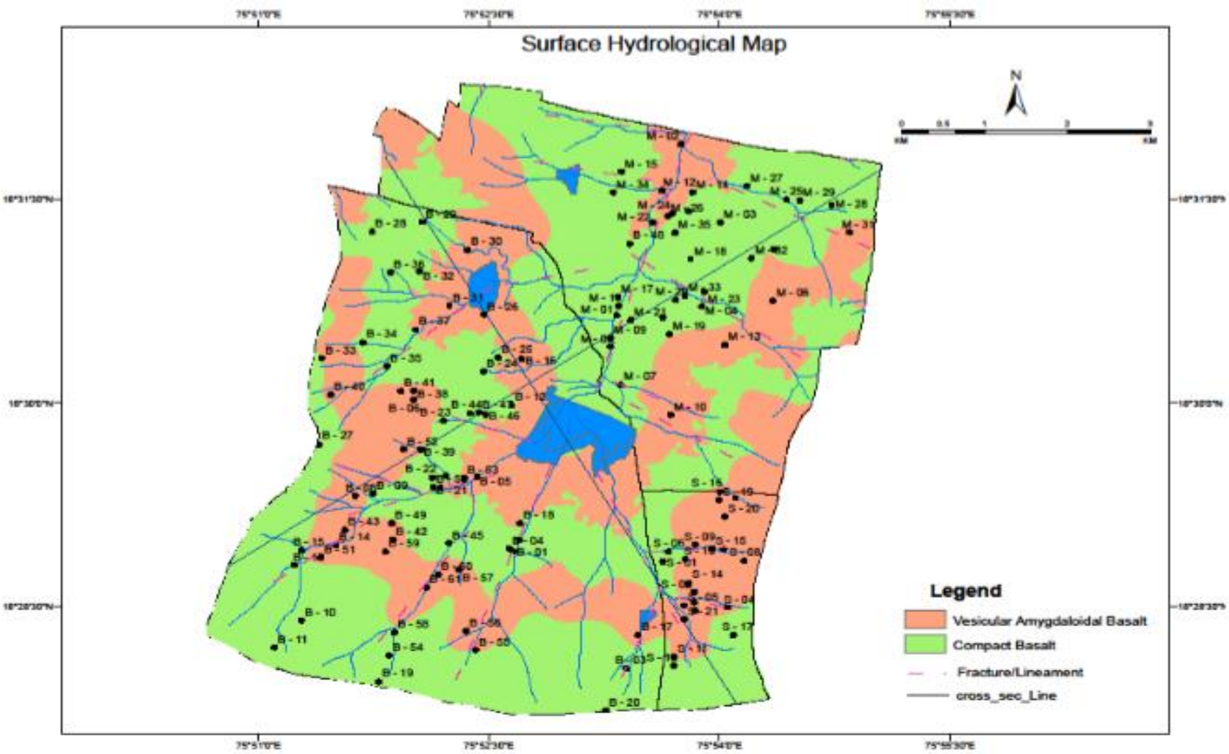


Fig.7 Surface Hydrological Map

- *Geological Traverses and Interpretation From Well Inventories:*

The complete area is divided into the grid of 600 x 400 m. for observations of surface and sub-surface hydro geology and groundwater level measurements (Fig-07). Each grid comprises the area of 24 Ha, thereby dividing the complete area of 4605 Ha into the 152 grids. There are 393 dug wells and 269 bore wells in the study area as per revenue record. One well (DW/BW) from each grid is surveyed and observed so as to cover the complete representation of the area. Accordingly 119 dug wells and 20 bore wells were observed during the field survey.

Drainages were also traversed simultaneously for mapping of surface geology and water conservation structures.

➢ *Occurrence of Groundwater in the Area*

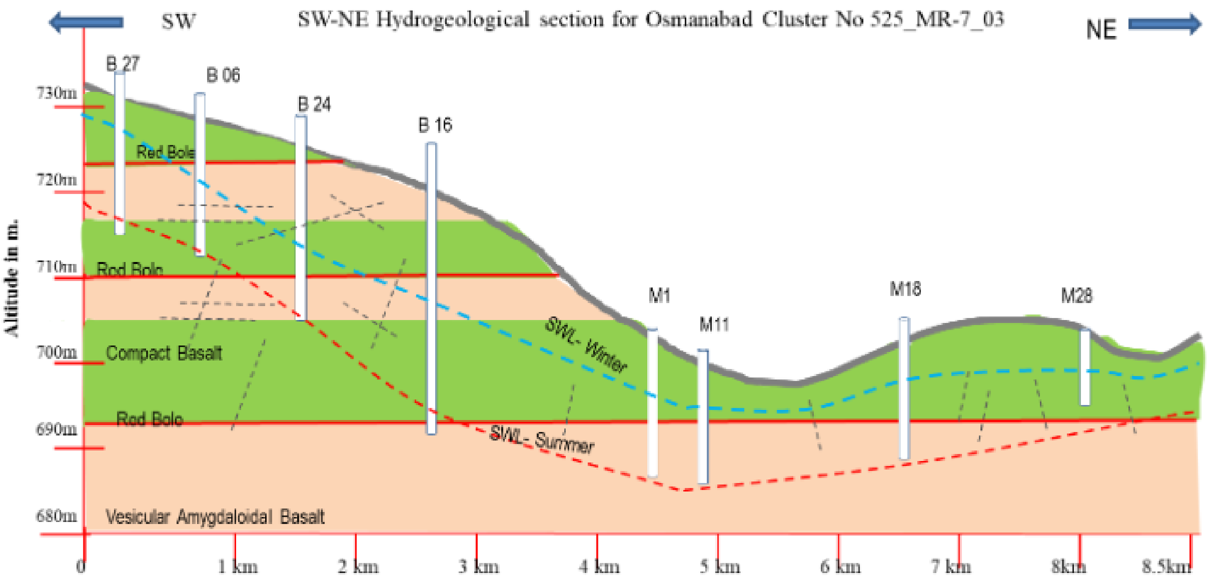


Fig.8 SW-NE Hydrogeological section for Osmanabad Cluster No 525_MR-7_03

Based on the actual field work done in the area, the total no. Dug wells in three village are 393 and Bore wells are 269 which are used for irrigation purpose, Out of 393, 119 dugwell and 20 borewells are actual surveyed at the time of field course. Average depth of the Dugwells are ranging in between 15to 20 m and for borewells are 100-150 m, Average static water level (in m bgl)in Winter is 3-7m, and in summer is 8-16m. Average annual Groundwater level fluctuation is about 6m (3-9m).

There are two aquifers are encountered in the area, one is shallow phreatic, depth ranging from 7-16m, which shows Altitude range in between 705- 725 mbgl , thickness of aquifers observed in the area average 8 m, Saturated thickness of shallow aquifer in winter 8-10m and in summer 1-2m. which shows three Basalt flows having average thickness of 13 to 15 m. The flows are of simple nature as the boundaries are clearly differentiated at some depths and locations by means of Red bole. Each flow has two sub units as, the vesicular amygdaloidal basalt (VAB) and the compact basalt (CB). Red bole layer or chilled margins separate the flow from each other. (Fig 8&9). Weathered and sheet jointed vesicular amygdaloidal basalt (VAB) and compact basalt acts as an aquifer in the area. Vertical and sub vertical joints are also observed in the VAB and CB sub units but are not prominent enough to provide potential specific yield to the aquifer. Therefore average specific yield of the shallow aquifer in the study area is around 1.3 % (0.013) as obtained by dry season specific yield method.

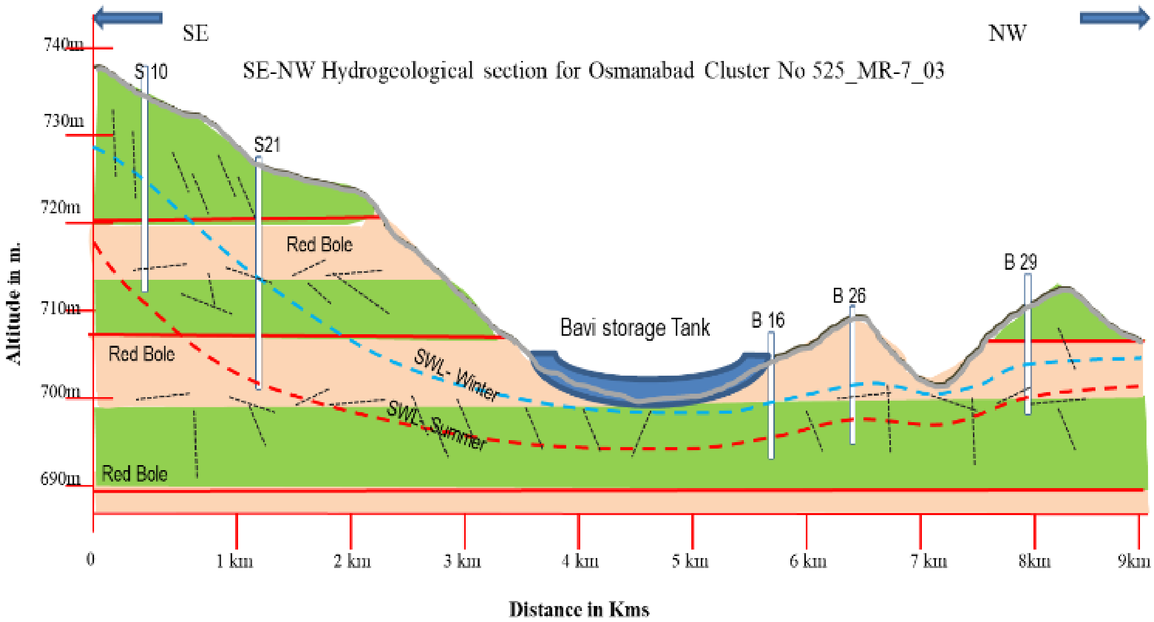


Fig.9 SE-NW Hydrogeological section for Osmanabad Cluster No 525_MR-7_03

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Below phreatic aquifer about 45-55m depth, there is another aquifer observed that is Semi confined aquifer which shows Vesicular amygdoidal basalt (VAB) and Compact Basalt (CB)with sheet joints, which shows altitude range in between 645- 635 mbgl, Thickness of aquifers observed in the area average 5m, and areal extension of both aquifers observed are 4172 H.

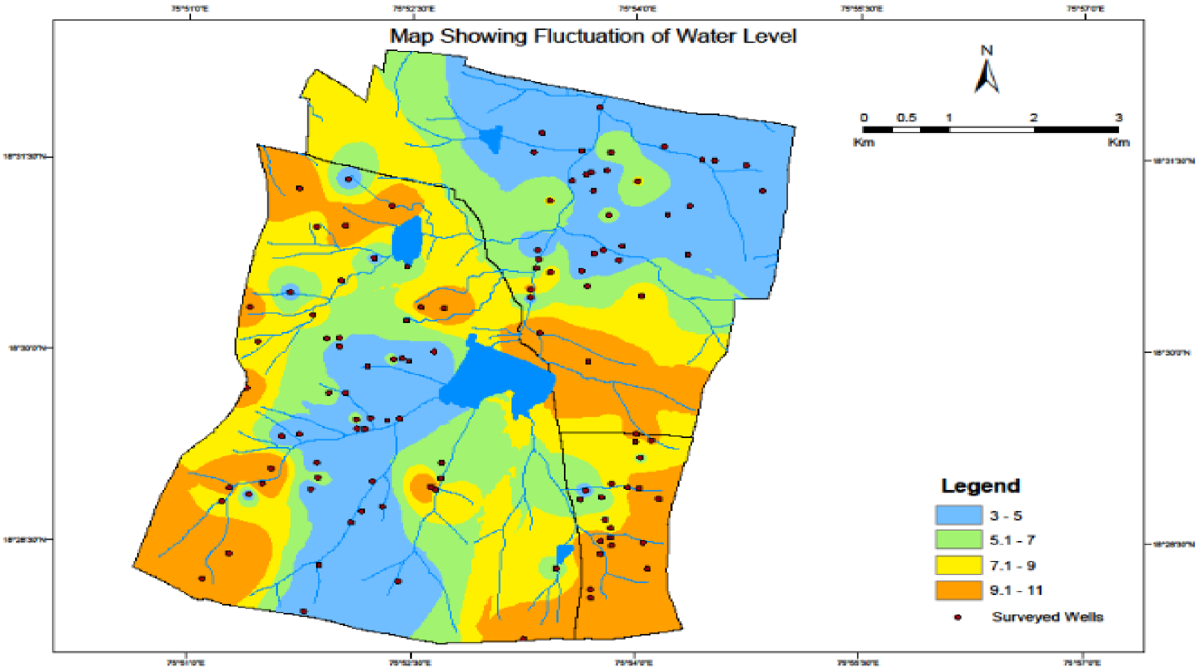

Fig.10 Fluctuation of Water Level

Depth to groundwater level in post monsoon(winter 2018) varies from 3 to 13 m bgl. However the depth to GW level between 3 to 7 m.bgl is more common. Depth to groundwater level map in Pre-monsoon (Summer 2019), varies from 6 to 18 m bgl. However the depth to GW level between 8 to 12 m.bgl is more common. Annual GW level fluctuates between 3 to 11 m. But major part of the area shows the GW fluctuations between 3 to 9 m. Thus average WTF for the study area is considered as 6 m. WTF is very less in the Mandva village area, whereas it is greater in Sonarvadi and southern Bavi areas. Thus, indicating heterogeneity in the aquifer behavior and hence in the groundwater recharge.

IV. ELECTRICAL RESISTIVITY METHODS

➢ *Resistivity Method:*

The main principle of resistivity method is based on the concept of resistivity. The electrical resistivity may be defined as the resistance offered by a unit cube of material to direct current flowing through it in a direction perpendicular to two of its opposite faces. The unit of resistivity is Ohm-meter.

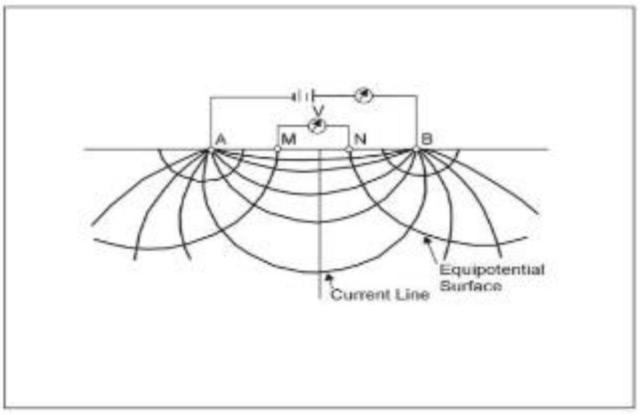

Fig.11 Resistivity Method

➢ *Field Procedure:*

Electrical resistivity method has been used mainly in the search for water bearing formations. A method of tracing changes of resistivity of formations with depth is known as vertical electrical sounding. The Vertical Electrical Soundings (VES) are carried out in the area to understand the subsurface geological formations and layer distribution. Three VES were carried in the mini watershed area. Starting from a small current electrode separation (AB/2) and one fifth of current electrode separation that is potential electrode separation (MN/2), the apparent resistivity is measured corresponding to successively increasing separations at the same reference point.

➢ *Schlumberger Configuration***:**

Schlumberger configuration was taken with a maximum half current electrode separation 150-200m (AB/2).A pre-determined set of current electrode separations with calculated geometric factors has been used for collection of sounding data.

The geometric factor is given by K=∏AM AN

MN

The apparent Resistivity (ρa) =˘K*R

Here K is geometric factor and R is resistance of the rock material.

➢ Instrumentation:

The Geophysical instrument Terrameter SAS 300C (Sweden) is used for the carrying the electrical resistivity survey. The instrument directly gives the resistance value for each current electrode separation, which when multiplied with the geometric factor, gives the apparent resistivity.

➢ *Interpretation:*

The apparent resistivity values are plotted against the current electrode separation AB/2 on the double log graph paper. AB/2 values on the y-axis and obtained values of resistivity on x-axis are plotted. The data were interpreted with the help of master curves and IPI2win resistivity software. The interpreted results show the true resistivity and its thickness. The interpreted results can be further utilized for preparing Iso resistivity section which gives the aquifer demarcation of subsurface geological formation.

The apparent resistivity values are divided into four zones with colors.

They are - Zone I : 5 to 50 ohm-m - Top soil
II : 50 to 80 ohm-m - weathered/fractured/jointed basalt
III : 80 to 100 ohm-m - vesicular/amygdaloidal basalt
IV : more than 100 ohm-m - Compact/Massive basalt

Vertical electrical Sounding (VES) data analysis of studied areas shows poor aquifer conditions, which confirm the sub surface hydrogeological observations are same as mentioned in preliminary geological set up of the area. The A type curves are identified in the area. This indicates poor groundwater potential in the area. Low resistivity value ranges gives low potential in the given area.

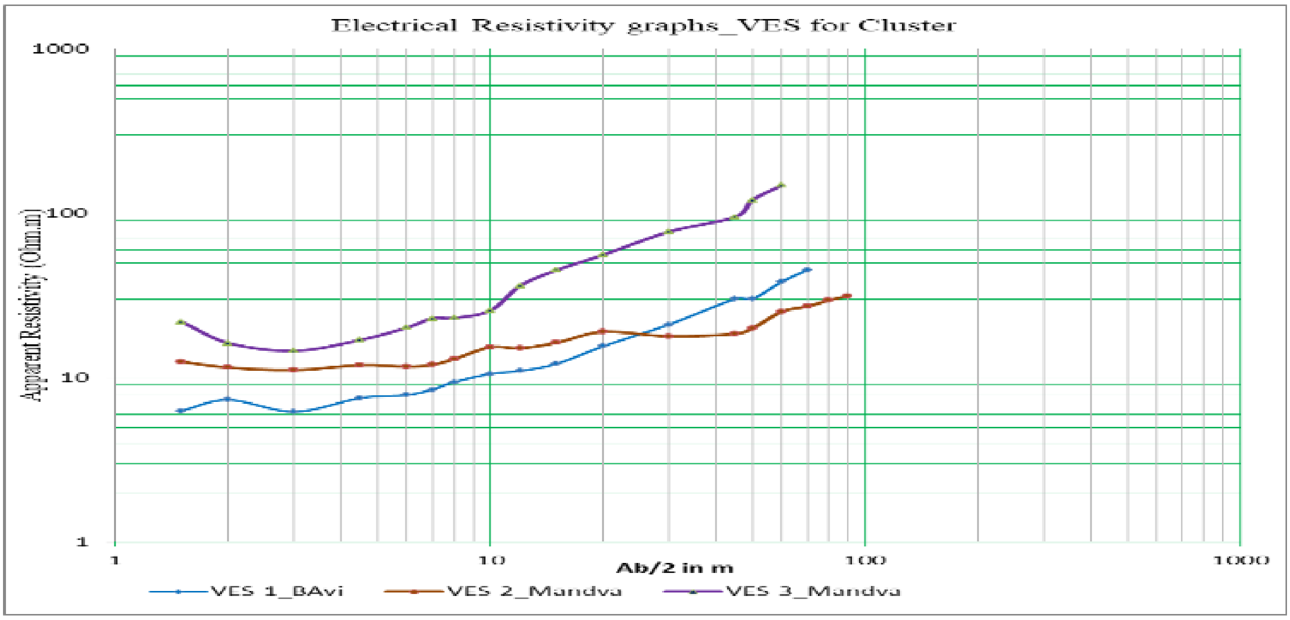

Fig.12 Electrical Resistivity Graph_VES For Cluster

Table 4.Groundwater Estimation of Study Area (2018-19)

Groundwater Draft Estimation (2018-19)								
	Village		Bavi		Sonarvadi		Mandava	
Sr.	Well Type		Dug wells	Bore wells	Dug wells	Bore wells	Dug wells	Bore wells
1	Total no. of irrigation wells in the area		204	124	29	30	160	115
2	Total no. of wells in use		204	124	29	30	160	115
3	Total no. of wells surveyed		63	8	21	4	35	8
4	No of perrenial wells (perrenial pumping)		122	90	18	30	150	100
5	% of perrennial wells (perrenial pumping)		59.80	72.58	62.07	100.00	93.75	86.96
5	Average depth of wells in the area in m		14	150	13	150	11	150
6	Average pump discharge/well /per hour (cum/hr)		20	18	20	18	20	18
7	Average pumping hours a day	June-Sept	2	4	2	6	2	5
		Oct-Dec	5	5	5	6	5	6
		Jan-March	2	4	4	6	3	4
		April -May	1	4	1	6	2	4
8	Average pump operation days	June-Sept	20	20	24	24	24	22
		Oct-Dec	20	20	34	34	30	30
		Jan-March	20	20	36	34	30	30
		April -May	32	30	24	24	28	28
		Total	92	90	118	116	112	110
9	Average annual draft of a well (unit draft) in Ham	June-Sept	0.08	0.14	0.10	0.26	0.10	0.20
		Oct-Dec	0.20	0.18	0.34	0.37	0.30	0.32
		Jan-March	0.08	0.14	0.29	0.37	0.18	0.22
		April -May	0.06	0.22	0.05	0.26	0.11	0.20
		Total	0.42	0.68	0.77	1.25	0.69	0.94
10	Total groundwater draft in the area in Ham	June-Sept	16.32	17.86	2.78	7.78	15.36	22.77
		Oct-Dec	40.80	22.32	9.86	11.02	48.00	37.26
		Jan-March	16.32	17.86	8.35	11.02	28.80	24.84
		April -May	7.81	19.44	0.86	7.78	16.80	20.16
		Total	81.25	77.47	21.86	37.58	108.96	105.03
		Total	**158.72**		**59.44**		**213.99**	
		Total	**432.15**	**Ham =**	**4321.54**	**TCM**		

Table 5. Groundwater Estimation

Groundwater Estimation		
Monsoon Recharge		**TCM**
1	Rainfall recharge during monsoon (by WTF) in TCM =(area × wtf × sy) (4605*7*0.013)	3254.16
2	Recharge from WCS during monsoon in Ham	47.00
3	Recharge from groundwater irrigation during monsoon in TCM (considered 10 % of water applied)	82.90
4	Groundwater Draft during monsoon in TCM	829.00
5	Recharge from Surface water irrigation during monsoon in TCM	0
6	Total groundwater recharge during monsoon in TCM =(1+2+(4-3))	**4047.26**
Non-Monsoon Recharge		
7	Recharge from WCS during non-monsoon in TCM	47.00
8	Recharge from canal in TCM	0
9	Recharge from Surface water irrigation during non-monsoon in TCM (10% of SW applied)	0.00
10	Recharge from Groundwater irrigation during non-monsoon in TCM (considered 10 % of water applied)	350.00
11	Recharge from Tanks and ponds in TCM (as per GEC norms)	35
12	Total groundwater recharge during non-monsoon in TCM (6+7+8+9+10)	**432.00**
13	Gross groundwater recharge (5+11) in TCM	4479.26
14	Net groundwater availability in TCM (11-(5%0f 13)) by deducting base flow	4255.30
15	Gross groundwater draft for all uses (from earlier sections) in TCM (Domestic+ Irrigation) = 231 +4321= 4552 TCM	4552.00
16	Stage of groundwater extraction (15/14) × 100 in %	106.97
17	**Groundwater surplus (+)/deficit(-) = 14-15 in TCM**	**-296.70**

With this above estimation of the study area, it is observed that the ***category*** of the study area is ***Over Exploited***. It is also inferred that GW recharge percent w.r.t. rainfall is almost 14 % (13.59%). This estimate gives a fair idea about the groundwater depletion in the area by 0.54 m/year.

➢ *Discussion*

In the study area, Rainfall pattern is very fluctuating and 2-3 dry spells in rainy season is very common. GW use exceeds the GW recharge thereby causing to deplete GW level in the area. Well density in the area is 13 to 17 wells per square Km, which is much higher than the safe limit of 8 wells per sq.km. With the falling GW level, depth of wells is consistently increasing years after years. Yield of wells reduced to 0.42 Ham (4.2 TCM) per well, thereby reduction in area irrigated per well (0.6 to 0.8 Ha).GW is used for filling up of Farm ponds, thereby increasing GW loss by evaporation rather than to use it for irrigation. Dug Cum bore well and bore wells are very common, but does not have substantial yield. 30 to 40 % wells are dry in summer. High well density and large no. of bore wells could be the main reason of GW level depletion. Groundwater samples from PWS wells of all the three villages were analyzed for drinking and agriculture purpose. Groundwater is suitable for both the purposes.

It would also be necessary to plan and control the use of groundwater under the prevailing conditions. Publication and distribution of annual reports and related programmes for creating awareness amongst the community and for educating them will have to be undertaken regularly. This will enable avoiding scarcity, as well as the hectic activity and excessive expenditure that has become characteristic of summer months. It is necessary to formulate and adopt a long-term policy to protect groundwater by preventing pollution and overuse. This policy should be comprehensive and implemented at all appropriate levels. It should be consistent with other water management policies and be duly taken into account in other sectoral policies. Priority is to be given for demand management measures supported by artificial groundwater recharge in all the over developed (over-exploited/critical/semi-critical) watersheds. Similarly the convergence of the GoI and GoM schemes of watershed development or artificial groundwater recharge need to be promoted in these areas. Unlike the land resource, groundwater is a dynamic resource. The groundwater flow cannot be measured like the flow through canals or pipe lines. The groundwater flows downward and spreads according to natural gradient and the permeability of the formations. Therefore, management of groundwater in fact, involves management of a dynamic, immeasurable and uncontrollable entity. While managing the groundwater resource, it is necessary to consider it to be a common property resource and is required to be controlled appropriately with the assistance of the community. Concepts like Village level Watershed Water Account, Village level Water Safety and Security, Basin/ Sub-basin Water Auditing, Aquifer delineation and its management etc will have to be popularized and made a basis for equitable distribution of ground water.

V. CONCLUSION

Optimum planning of GW recharge and need to control the irrigation draft less than the recharge. Application of Regulatory measures for not drilling bore wells. Optimum use of water saving practices. There should be annual GW budgeting on regular basis, need to plan cropping as per GW availability. Need to discourage groundwater use for filling farm ponds. There are water conservation and groundwater recharge structures are proposed in the study area , like Recharge Shafts, Recharge Trenches with shaft , Gabbion, K.T. weirs repair, and simultaneously existing water conservation structures should be repaired and maintained.

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