Geophysical Studies and Artificial Groundwater Recharge Plan at RGUKT Nuzvid Campus

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Abstract - Ground water is the major source of water to meet the requirements of domestic, industrial and irrigation in India. Even though the planet of earth has 97% of water, the fresh water availability is only 2.5%. Ground water is a critical resource in India, accounting for over 65% of irrigation water and 85% of drinking water supplies. These resources are depleting day by day by extracting the ground water from the bore wells.

Climatological, Geological, Geomorphological, Geo hydrological studies along with ground water level fluctuations in the study area helps to understand the ground water regime. So, geophysical surveys were carried out by using resistivity methods. The current study focusses mainly on feasible solution to the scarcity of ground water resources in one of the over exploited region of Krishna district, i.e., RGUKT, Nuzvid. The study area depends only on the ground water resources. One of the ways to sustain the same is recharging groundwater by constructing recharge pits.

Ground water recharge is done by observing the weekly ground water table fluctuations in the study area by measuring the ground water levels in the bore wells with the help of ground water level indicator equipment. The current study focused on "Roof top Rain Water Harvesting" for storing and utilizing the rain water, also for recharging the ground water. This leads our environment to be in the greenish envelop. Therefore, this would be a feasible solution to build a green city.

Keywords* —Groundwater, *Geo-physical studies, Geo-hydrological studies, resistivity method, Rain water harvesting, Artificial recharge.

I. INTRODUCTION

Water is a precious natural resource, which is vital for life, development and the environment. 70% of the earth's surface is covered with water. In which 97% of water on earth is saline and only 3% is available as fresh water. About 77% of this fresh water is locked up in glaciers and 11% is considered to occur at depths exceeding 800 m below the ground, which cannot be extracted economically with the technology available as of now. About 11% of the resources are available as extractable ground water within 800 m depth and about 1% is available as surface water in lakes and rivers. Ground water, which is the source for more than 85% of India's rural domestic water requirements, 50% of its urban water requirements and more than 50% of its irrigation requirements. It is not only the main source for water supply in urban areas for domestic uses, but also is the largest and most productive source of irrigation water, which is depleting in nature. Therefore, it is indispensable to evaluate in the aspects of hydrology, hydrogeology, hydro chemical etc. In this connection, the concept of basin studies is adopted to understand the ground water system. It may be useful for these studies.

Ground water is depleting fast in many areas due to its large-scale withdrawal for various sectors. Out of a total of 5723 assessment units (Blocks/Mandal's/Talukas) in the country, 839 have been categorized as 'Overexploited'. Around 226 'Critical' assessment units has its ground water draft between 90 and 100% of the annual replenishment, apart from 30 blocks having only saline ground water [3]. To Study the aspects of hydrology, hydrogeology, hydro chemical of ground water etc., the concept of basin studies is adopted to understand the ground water system. The concept of basin studies is adopted for understanding the ground water regime and evaluation of quantity. The main objective of these studies is to develop the ground water resources for beneficial use, utilize the water resources at optimum level with integrated approach of both surface water and ground water resources. To evaluate replenishment of groundwater sources of Krishna district, it is divided in to 57 watersheds. In which 27 ground watersheds fall in upland

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and the remaining in delta region. The Ground Water Department, Government of Andhra Pradesh has taken up estimation of groundwater resources in the district with 2008-09 as the base year. From the previous assessments, Nuzvid watershed fall in over exploited category [9].

Natural replenishment of ground water reservoir is a slow process and continues exploitation of ground water resources in various parts of the country leads to declining the ground water levels. Artificial recharge efforts are basically aimed at augmentation of the natural movement of surface water into ground water reservoir through suitable civil construction techniques. Groundwater recharge is defined as 'the entry into the saturated zone of water made available at the water table surface together with the associated flow away from the water table within the saturated zone [7]. Roof top rainwater harvesting is one of the appropriate options for improve the ground water recharge, which can supplement the domestic requirements in rural areas as well. The concept of rainwater harvesting involves 'tapping the rainwater where it falls'. A major portion of rainwater that falls on the earth's surface runs off into streams and rivers and finally into the sea. An average of 8-12 percent of the total rainfall recharge only is considered to recharge the aquifers. The technique of rainwater harvesting involves collecting the rain from localized catchment surfaces such as roofs, plain/sloping surfaces etc., either for direct use or to augment the ground water resources depending on local conditions. Construction of small barriers across small streams to check and store the running water also can be considered as water harvesting. Therefore, the current study focused on ground water scenario of RGUKT-NUZVID campus and a recharge pit is designed for roof top catchment to increase the ground water levels.

II. STUDY AREA

A. INTRODUCTION

RGUKT-Nuzvid is in Krishna district Andhra Pradesh, which has Latitude and Longitude of 16.7911° N, 80.8226° E. It belongs to Nuzvid revenue and Ramileru basin, which is the one of the basin in Krishna district. Total area is 105.6 acres. Study area location belongs to toposheet of the survey of India No.65D/13. The source of water is ground water only. In future, we coming to know that there is a plan to use the sager water to satisfy the needs of RGUKT.

The Ground Water Department, Government of Andhra Pradesh has taken up estimation of groundwater resources in the district with 2008-09 as the base year. In the last two assessments, our college in over exploited category.

Generally Geological, geophysical and hydro geological studies are together taken up for ground water investigations. Understand the things is useful to develop ground water i.e. construction of any artificial structures for recharge and solving the ground water problems like ground water pollution, fluoride problem etc.

B. CLIMATE

Andhra Pradesh state Climate is generally hot and humid. The major role in determining the climate of the state is played by South-West Monsoons. Summers in Andhra Pradesh last from the month of March to June. During these months the mercury level is quite high. In the coastal plain the summer temperatures are generally higher than the rest of the state. In summer, the temperature is generally ranges between 20^{o}C and 40^{o}C, and at certain places the temperature is as high as 45 degrees [5].

Geology is the most important parameter which will decide the occurrence of the ground water. The main source of the ground water is sedimentary rocks eg: sand stone and lime stone etc, in weathered position, fractures and joint zones of the igneous rocks etc.

C. GEOLOGY OF THE STUDY AREA

Three geological formations are observed in our college is Khondalite which igneous rock (primary rock) and which has no porosity. It is consolidated formation. In consolidated formations ground water occurs under unconfined to semi confined conditions. These do not have any impermeable beds above them and the water table is under atmospheric pressure only. Depending on the water tapping from the aquifer or recharge into such aquifer the water table will fall or rise uniformly throughout the rock.

Ground water is extracted in these formations by dug wells, dug cum bore wells and bore wells tapping weathered and fractured zones. The yields are in the range of 20 to 70 m^3/day. The occurrence of fractures in the crystalline formations is limited down to 30 to 40 m bgl and occasionally extends down to 70 - 100 m bgl. The bore wells constructed in the crystalline formations generally tap the weathered and fractured zones. The yields of the bore wells generally range between 80 to 400 m^3/day [3]. The higher yields are limited to the available thickness of fractured and jointed zones.

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D. FIGURES

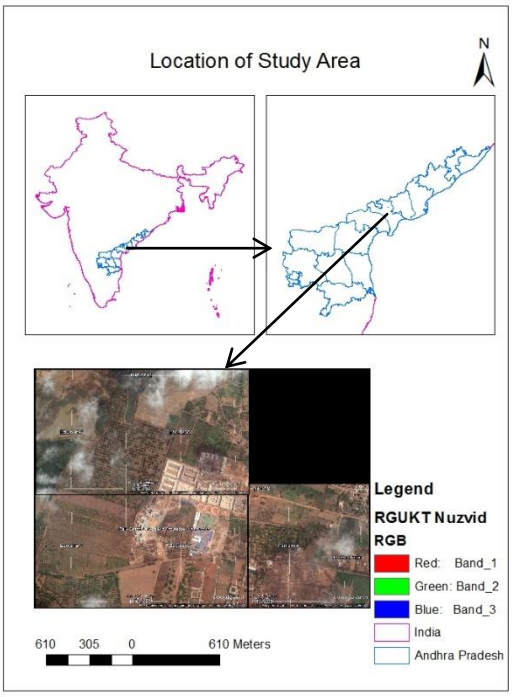

Fig.1. Study area location map

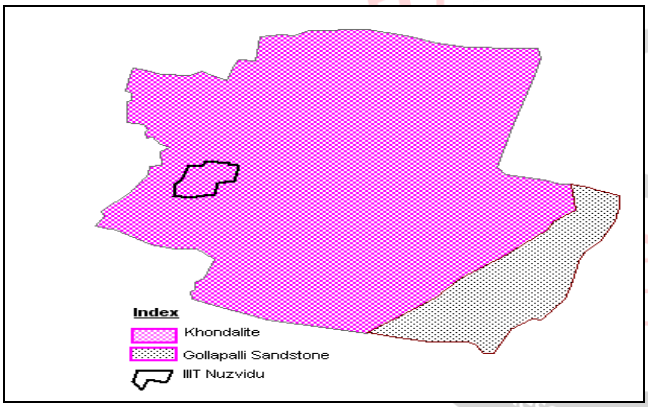

Fig. 2. Geology Map of Study Area

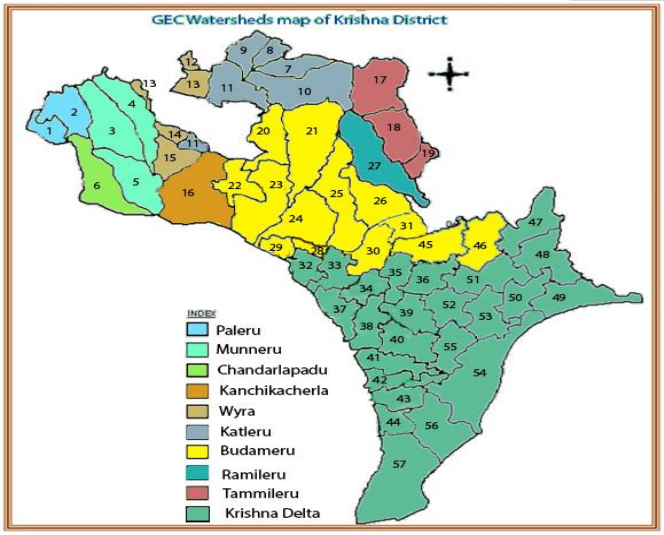

Fig. 3 Watershed map of Krishna District

III. GEOPHYSICAL SURVEYS

Geophysics is the study of the earth by making use of established principles of physics. Geophysical studies involve simple methods of study made on the surface with the aim of ascertaining subsurface details. Geophysical surveys were conducted at study area to locate the bore well positions to extract the water. 15 sounding test data analyzed and plotted the counters of soil, weathered, semi weathered zones of study area [4]. If weathering zone is more the storage capacity of aquifer is more.

General geophysics deal with various physical fields like gravity field, magnetic field, geothermal field. Exploration geophysics deal with exploration of oil, gas, ore deposits, ground water and solving certain problems of engineering geology. There are so many kinds of geophysical methods of investigation grativity, electrical, seismic, radiometric and geothermal methods. All geological formations have a property called electrical resistivity which determines the ease with which electric current flows through them. This resistivity expressed in terms of ohm-m and it is indicated with symbol ‘p’. Most of the rock forming minerals have high resistivity, whereas sulphide minerals have high conductivity. Quartz-(1014-1016) Ohm-m, Granite –(103-105)Ohm-m, sand stone –(10-103) Ohm-m etc [10].

IV. CLASSIFICATION OF RESISTIVITY METHODS

A. PROFILING

This is also known as electrical profiling or lateral electrical investigation. In this process, the electrode set-up is moved from place to place with the same electrode intervals along the chosen profile and pa is measured at each station. The changes in pa indicate lateral variations in the subsurface corresponding to a certain depth. If the current electrode separation is more, the depth of investigation is more. The results plot on graph taking pa on Y-axis and AB/2 on X-axis. In profiling is done by wenner method is shown in figure 4.

B. SOUNDING

This method is properly known as vertical electrical sounding (VES). It is also known as “electrical probing”. In this method pa values measured at same place by increasing the distances between the current electrodes each time after taking the reading**.** This kind of successive increasing in distance makes the current penetrate more and more deeply. Hence the change in pa values measured indicate the vertical (i.e., depth wise) variations in the subsurface at the investing point as shown in figure 5. This VES data is interpreting by matching curves method or Inverse Slope method. Sounding is done by **Schlumberger method**.

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Table. 1 Field observation values

RGUKT- NUZVID							
VES DATA SHEET							
VILLAGE:	IIIT -NUZVID		Date:				
MANDAL:	NUZVID		Geology:	Kondalite			
SCHEME:	Project						
Latitude:	16°53'18.05"						
Longitude:	80°51'52.05"						
AB/2	MN/2	K	VES: 01				
			a	V	I	Pa	(AB/2)/pa
1.5	0.5	6.3	1	251	49	32.20	0.0466
3	1	12.6	2	115	72	20.08	0.1494
6	2	25.1	4	136	241	14.19	0.4229
9	3	37.7	6	100	304	12.41	0.7255
12	4	50.3	8	24	113	10.68	1.1236
15	5	62.9	10	24	180	8.38	1.7898
18	6	75.4	12	22	231	7.18	2.5057
21	7	88.0	14	93	1300	6.30	3.3358
24	8	100.6	16	28	493	5.71	4.2017
27	9	113.1	18	18	405	5.03	5.3693
30	10	125.7	20	12.6	293	5.41	5.5492

From the above observations, the graph is plotted between apparent resistivity versus current electrode separation in meters as shown in the figure below.

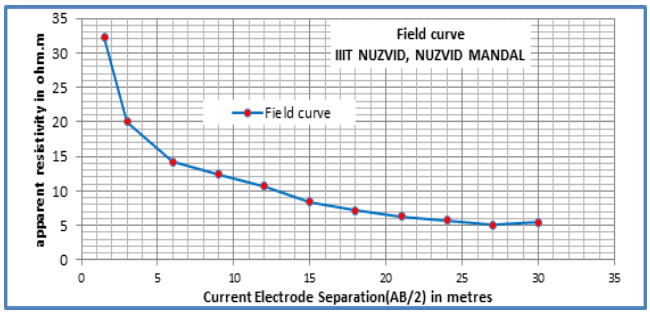

Fig. 4. Field Graph (AB/2 Vs pa)

The inverse slope method is used for interpreting VES conducted by Wenner configuration. This plot gives the resistivity with respect to the depth of the soil profile below the ground level.

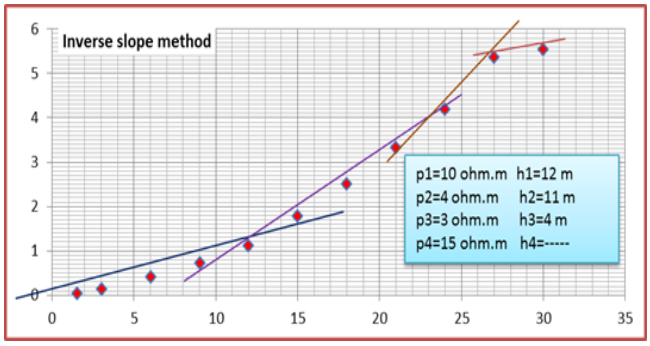

Fig.5. Thickness of each zone by Inverese slope method

C. CONTOUR MAPS OF STUDY AREA

Sounding tests were conducted to locate the borewell points. 15 sounding data used to draw the contours of soil zone, weathered and semi weathered zones of the study area. Contour maps of soil thickness, weathered layer thickness and semi weathered layer thickness of the study area were shown in the figure 6, 7 and 8. Also, the flow pattern at the study area was plotted and shown in figure 9, shown below.

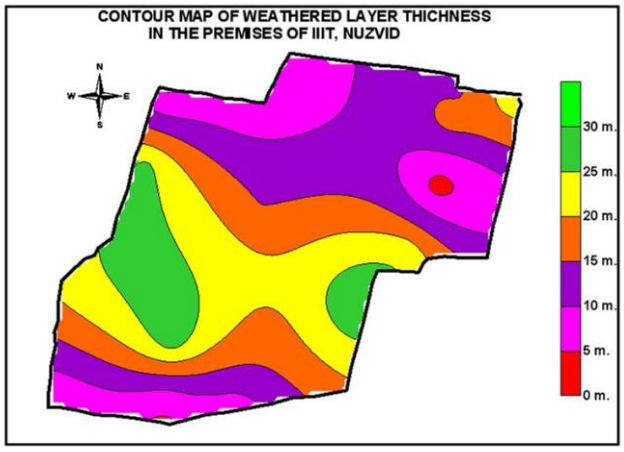

Fig. 6. Contour map of soil thickness

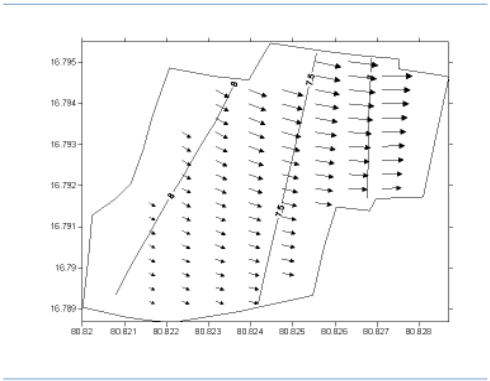

Fig. 7. Contour map of Weathered Layer thickness

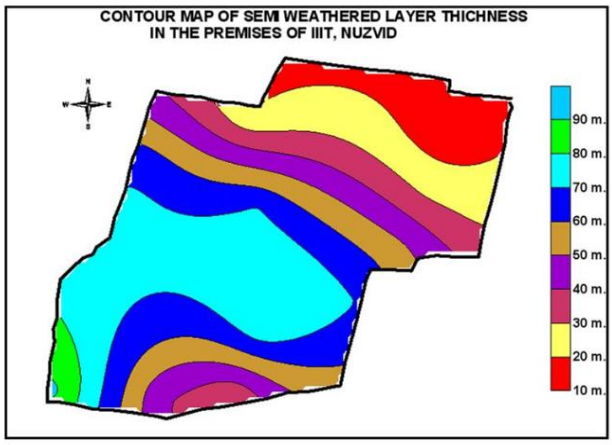

Fig.8.Contour Map of Semi-Weathered layer thickness

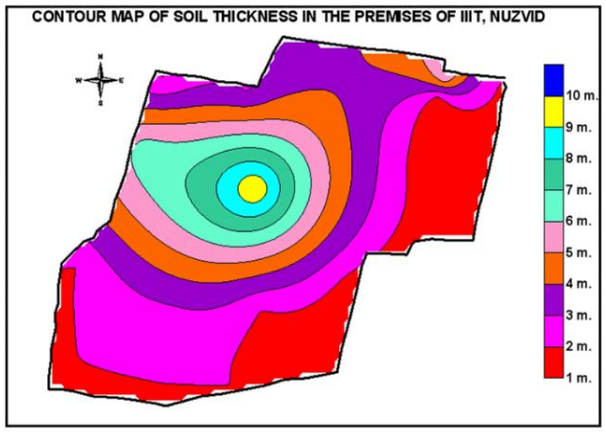

Fig.9. Flow direction map of study area

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From the figure 6, the soil depth varying from 1 to 10 m in the study area. From the figure 7, maximum weathered zone area is having highest water holding capacity. So, recharge pits are preferably constructed in that region.

V. GEOHYDROLOGICAL STUDIES AND WELL LOCATIONS

It also be called as hydro geology. It deals with the occurrence, movement and nature (quality and quantity) of the ground water in an area. Bore wells are used to extract is a well which is using in hard rock areas to extract the ground water. In this up to the hard rock in sub ground casing is required. The number of bore wells existed in the campus is 16 as shown in figure 10. At present, out of 16 bore wells 12 bores are running 24 hours to satisfy our needs as shown in the table 2. The power of submerged motor pumps (SMPS) are varying 5hp to 7.5hp to extract the ground water through bore wells. However, ground water is the only source to satisfy the needs. Also, the water level contour map of the study area is plotted in figure 11. This rain water harvesting system is economically cheaper in construction compared to all other sources, i.e., well, canal. Dam, diversion etc. [1]

Table. 2 Working Bore well Locations

S.No	Location of Bore Well	Latitude	Longitude
1	Eta Block	16.796	80.831
2	Workshop	16.798	80.832
3	K4 opposite corner	16.799	80.836
4	STP plant corner	16.802	80.835
5	K3 hostel inside	16.799	80.834
6	K2&K3corner	16.717	80.833
7	K2 opposite ground	16.802	80.833
8	N-Type block	16.802	82.327
9	M1&O1middle	16.805	80.831
10	A3 opposite	16.797	80.825
11	A4 Backside	16.795	80.823
12	In front of I3	16.800	80.826

FIG. 10. LOCATION OF 16 BOREWELLS

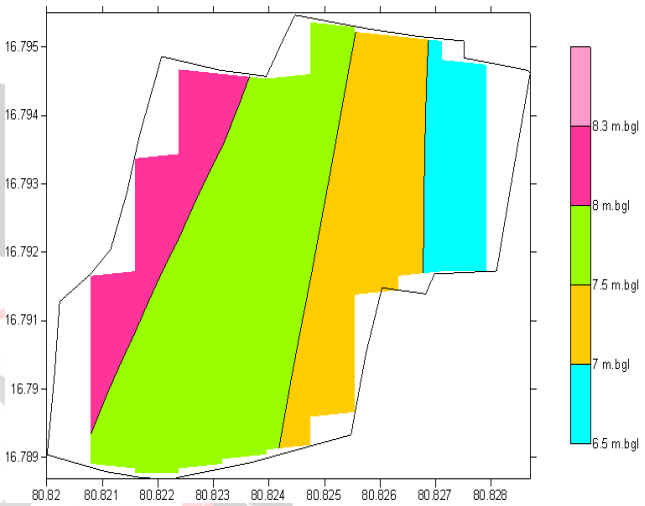

FIG. 11. WATER LEVEL CONTOUR MAP

A. RAINFALL DATA AND WATER LEVEL FLUCTUATIONS

The water level is the upper surface of the zone of saturation. It is resultant of atmospheric pressure on aquifers. It is called water table in unconfined aquifers and potentiometric surface in confined aquifers. There is a possibility of fluctuation in water table mainly because of Rainfall, Evapotranspiration, Pumping and urbanization. So, water level fluctuations were measured for five months (December to April) at few borewells, where the extraction is at high rate.

Water levels in the bore wells were continuously monitored using “water level indicator” equipment. Due to seasonal variations, water levels are fluctuating continuously. Even with small rainfall occurrence also shows variation in the levels. Although our Nuzvid Campus depends mainly on ground water for the water usage. The rainfall data of six years (2008 to 2013) for Nuzvid area was collected from MRO office, Nuzvid and plotted graph for the same as shown in the figure. The average annual rainfall for Nuzvid is 1407 mm.

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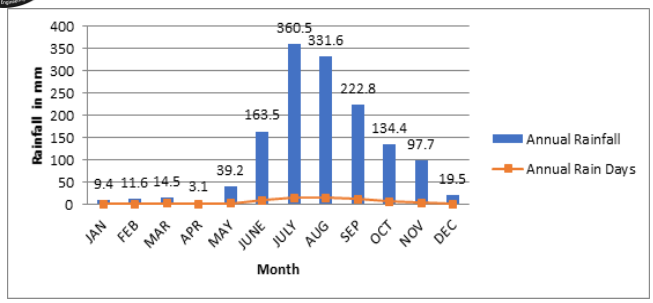

Fig. 11. Annual Rainfall and number of rainy days in each month

Four number of bore wells were identified, where the extraction rate is very high. Water levels of those bore wells are monitored before and after switching on the motor and plotted in the figure 12.

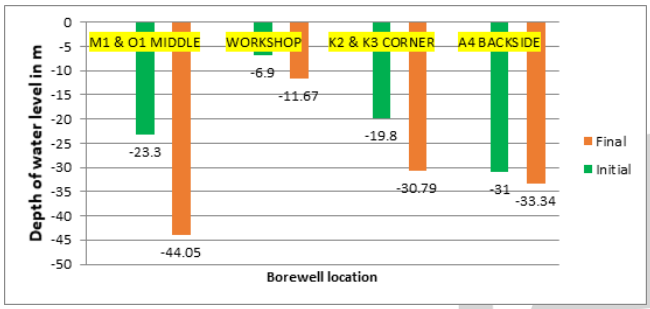

Fig.12. Water level depth before and after switching on the motor

From the above plot, it depicts that the water level is declining rapidly at M1 & O1 middle borewell. So, it is proposed to construct recharge pit at that location.

B. DESIGN OF RECHARGE PIT BY USING ROOF TOP RAIN WATER HARVESTING

After performing Geo hydrological studies and Geo physical observations, the recharge pit was proposed at middle of M1 & O1 blocks as shown in figure 13. For designing the optimum capacity of pit, Size of the catchment, Intensity of rainfall and Rate of recharge parameters were considered, which depends on the geology of the site [6].

The rate of recharge in comparison to runoff is a critical factor. However, since accurate recharge rates are not available, the rates should be assumed [7]. Runoff coefficient was taken as 0.6 [2].

Area of the catchment (Roof top) =380.18m^2
Rainfall=1.407m
Volume=380.18m^2 * 1.407m =534.54m3
Tank Size=0.6*534.54=320.7m^3
5% Considered for Pit Size=320.7*0.05=16.6=18m^3
By considering Rectangular Pit,
Length =3m; Width =2m; Depth =3m and Total Volume=18m^3.

After constructing recharge pit at the proposed location, ground water level increased rapidly with a thunderstorm, occurred in the month of April. The Initial ground water level is measured as 44.05 m and after a thunderstorm, ground water level using water level indicator was measured as 40.55m.

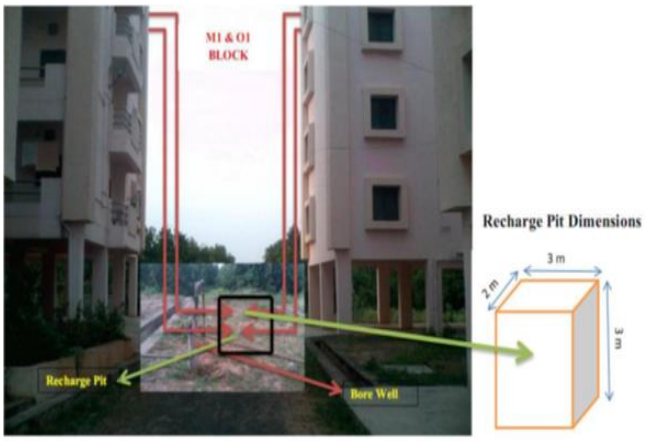

Fig. 13. Proposed location and dimensions of the recharge pit

VI. RESULTS AND CONCLUSIONS

Due to rapid industrialization in present scenario, there is lot of groundwater withdrawals taken place in Nuzvid. Groundwater recharge plays a vital role in hydrogeologic studies. Geo physical studies were performed to analyze the soil profile with respect to its soil thickness by inverse slope method. Hydrogeological surveys were performed to obtain the trend of water levels in bore wells, further water level contour map was prepared. After performing detailed study on water level fluctuations by using water level indicator equipment, four bore wells were identified where the extraction rate is more than the recharge. A recharge pit was "constructed in one of the bore well (middle of M1 & O1), where the water levels are declining rapidly. After the construction of recharge pit, water level in the bore well was gradually increased to 3.5 m with a small intensity thunderstorm. Therefore, the constructed rain water harvesting pit effectively recharged the ground water and hence the water level was increased.

ACKNOWLEDGMENT

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