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ROOFTOP RAINWATER HARVESTING STRUCTURES DESIGN AT JNTUH HYDERABAD CAMPUS

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Abstract: Present study deals with the study of impact of artificial recharge of roof top rainwater on the quantity and quality of groundwater and Designing the structures to catch hold of rain water. Geomatic approach was employed for identifying sites for construction of roof top rainwater harvesting structures by preparing various spatial maps. Monitoring and assessment of groundwater levels was carried out in the study area. Normal annual rainfall in the campus of Jawaharlal Nehru Technological University Hyderabad is 821mm with unutilized non-committed surplus monsoon runoff. Artificial recharge of ground water through rooftop rainwater harvesting was done by constructing three recharge structures each with a capacity of 1,00,000 liters. Three measuring bore wells (Piezometers) with a diameter of 6" were dug up to a depth of 30 m near the recharge structures for impact assessment studies. Water levels measured in the three bore wells on daily basis during the monsoon period were found to be 25.87 m, 27.04 m 11.47 m on 15th June 2012, and the corresponding water levels have been improved to 16.66 m, 18.07 m, 3.3 m respectively on 5th December 2012. A corresponding rise of 9.21m, 9.97m, 8.17 m in groundwater levels has been registered indicating significant improvement of groundwater levels. Rainfall received during the months of June, July, August and September ,October, November 2012 was found to 200.1 mm, 193.2 mm, 170.0 mm , 94.8 mm ,61.6mm,and 55mm respectively. A total rainfall of 774.7 mm has recorded and a total quantity of 27, 73,426 liters of groundwater has recharged during the four months period in the campus. Monthly recharge of groundwater through roof top rainwater harvesting from the three roof areas in the campus during the above months are 7,16,358 liters (in June), 6,91,656liters (in July), 6,08,600 liters (in August), 3,39,384 liters (in September), 2,20,528liters (in October) and 1,96,900 liters(in November) respectively. The design of storage tank and recharge pit was done for Type A1 and B1 quarters near by stadium at JNTUH campus. According to W.H.O, CPCB, APPCB, and IS 10500.The above harvested water doesn't meet their permissible limit, so this water is not potable for drinking purposes and only useful for domestic purposes, gardening. By adapting different advanced treatment techniques water can be used for drinking purposes.

I. INTRODUCTION

Water is one of the most commonly used substances on our earth. We need water for all our activities in day-to-day life. Water supply in urban area is always short against the total demand. Surface water is inadequate to meet our demand and we have to depend on ground water. Due to rapid urbanization, infiltration of rainwater into the subsoil has decreased drastically and recharging of ground water has diminished. This scenario requires an alternative source to bridge the gap between demand and supply. Rainwater, which is easily available and is the purest form of water, would be an immediate source to augment the existing water supply by "catching water wherever it falls".

Rainwater Harvesting (RWH) is the process of collecting and storing rainwater in a scientific and controlled manner for future use.
Rainwater harvesting in urban areas include
Roof top rainwater harvesting
RWH in paved and un-paved areas (open fields, parks, pavement landscapes etc.)
RWH in large areas with open ponds, lakes, tanks etc.

Uses of rain water harvesting

1. Environment friendly and easy approach for water requirements
2. RWH is an ideal solution for areas having inadequate water resources
3. Increases ground water level
4. Improves ground water quality
5. Mitigates the effects of drought
6. Reduces the runoff, which otherwise flood storm water drains
7. Reduces flooding of roads and low-lying areas
8. Reduces soil erosion
9. Cost effective and easy to maintain.

3.0 Methods of RWH

Rainwater Harvesting from runoff:

Rainwater stored for direct use in tanks above ground or underground sumps or overhead tanks and used directly for flushing, gardening, washing etc.

Ground water recharge

Recharged to ground through recharge pits, dug wells, bore wells, soak pits, recharge trenches, etc. Rainwater harvesting potential in urban areas is huge. Considering the availability of rainwater in a residential site of 40 x 60 feet (an area of 2400 sq.ft./223 sq.mts.), around 2,23,000. Its of rainwater can be harvested in a location where the rainfall is around 1000 mm or 39.4 inches (Bangalore receives around 1000 mm of rainfall annually). The amount of rainwater that can be harvested from the available rainwater in the plot depends on potential rainfall, catchment area available, collection methods and its efficiency etc.

4.0 Objectives of the Present Study

- To record daily rainfall from Symons rain gauge located at Meteorological station in Jawaharlal Nehru Technological University, Hyderabad.
- To monitor daily water levels in rainwater harvesting structures located in the Jawaharlal Nehru Technological University Hyderabad.
- To monitor daily groundwater levels trough three Piezometers located near roof top rainwater harvesting structures.
- To find out the amount of rain water that is harvested through RWH.
- To analyze physical and chemical water quality parameters before and after recharge of roof top rainwater.
- To design the storage tank and recharge pit for rain water harvesting at selected buildings.

5.0 Literature review

Rain water harvesting (RWH) primarily consists of the collection, storage and sub sequent use of capture drain water as either the principal or as a supplementary source of water. Both potable and non-potable applications are possible (Fewkes, 2006).Examples exist of systems that provide water for domestic, commercial, institutional and industrial purposes as well as agriculture, livestock, groundwater recharge, flood control process water and as an emergency supply for firefighting (Gould&Nissen,1999;Konig,2001; Datar, 2006).

The concept of RWH is both simple and ancient and systems can vary from small and basic, such as the attachment of a water butt to a rain water down spout to large and complex, such as those that collect water from many hectares and serve large numbers of people (Leggettetal, 2001).Before the latter half of the twentieth century, RWH systems were used predominantly in area slacking alternative forms of water supply, such as coral islands(Krishna, 1989) and remote, a rid locations lacking suitable surface or ground water resources (Perrens, 1975).Gould & Nissen(1999) provide a detailed history of rainwater harvesting systems. The authors state that, while the exact origin of RWH has not been determined, the oldest known examples date back several thousand years and are associated with the early civilization so the Middle East and Asia. In India, evidence has been found of simple stone-rubble structures for impounding water that date back to the third millennium BC (Agarwal & Narain, 1997). During the twentieth century the use of rainwater harvesting techniques declined around the world, partly due to the provision of large, centralized water supply schemes such as dam building projects, ground water development and piped distribution systems. However, in the last few decades there has been an increasing interest in the use of harvested water (Gould&Nissen1999) with an estimated 100,000,000 people worldwide currently utilizing a rainwater system of some description(Heggen,2000).

6.0 Study Area

Hyderabad city is situated in the Krishna basin and the river Musi, which is a tributary of river Krishna, passes through the city and bifurcates it into Northern and Southern Hyderabad. The Study region covers an area of 179Km² and is situated between 782°2'30"& 78°32'30" 'East Longitude & between 17°18'30"& 17°28'30" 'North latitude. The ground levels vary from 487 meters to 610 meters above mean sea level. The region of interest for site selection includes all area, which falls within the buffer distance of 50 km from the center of Hyderabad city. This area comprises of Hyderabad Urban Development Area, parts of Rangareddy, Nalgonda, Medak and Mahabubnagar districts of Telangana. It is covered by Topo sheet No. 56K on 1:2, 50,000 scale. The city stands on gray and pink granites as foundation materials, which is suitable for building construction

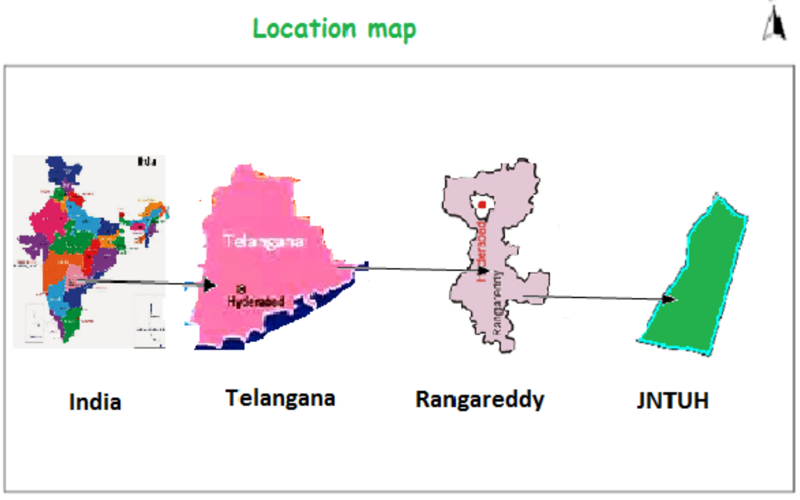
JNTUH is situated in the heart of the city at Kukatpally a major land mark. The study area describes JNTUH campus, Kukatpally, Rangareddy part of Telangana. This University has been deemed an autonomous one after Act No.30 of the approval of the Andhra Pradesh legislature known as the Jawaharlal Nehru Technological Universities Act, 2008 which came in to force on 18th August, 2008.The territorial jurisdiction of the University covers the areas of Hyderabad. The study area is located in the Ranga Reddy district and lies between North latitudes 17°30' and 17°29' and East longitude 78°23' and 78°24' and is covered in the survey of India Topographical map number 56 k7. This area is an elevation of about 591 meters above the mean sea level. The study area is very well connected by the Hyderabad – Bombay National Highway-7. Kukatpally is a major residential and commercial suburb in Hyderabad. It is located on the north west fringe of Hyderabad city. It was earlier a municipality, has been merged into Greater Hyderabad Municipal Corporation (GHMC) which is responsible for the civic amenities in Kukatpally.
New road connectivity and consequent proximity to the Information Technology hub of Hi-Tech city has made Kukatpally area a functional, dream home. It is segregated by medium as well as posh Phases, and Kukatpally Housing Board Colony developed by Andhra Pradesh Housing Board is considered to be the biggest colony in India and Asia Metro station is close to KPHB colony run by Indian Railways called as MMTS, and connects to Hyderabad and Secunderabad and is often the best way for getting to the other side of the city.

Within the study area (JNTUH), we have Piezometers for the observation of daily ground water levels , Rain water harvesting structures are constructed at different locations of the campus, we measured quantity of rain water collected in these tanks for each rain fall in this season . The circular is constructed at Manjeera hostel for collection and reuse of rain water for hostel boys. We observed runoff from this tank. This tank is useful for the evaluation of Coefficient of Runoff for roof tops. Within the campus many bore wells are drilled . Some them are working and others not working. Rain water will be recharged to these bore wells , location of bore wells shown in figs bore wells .

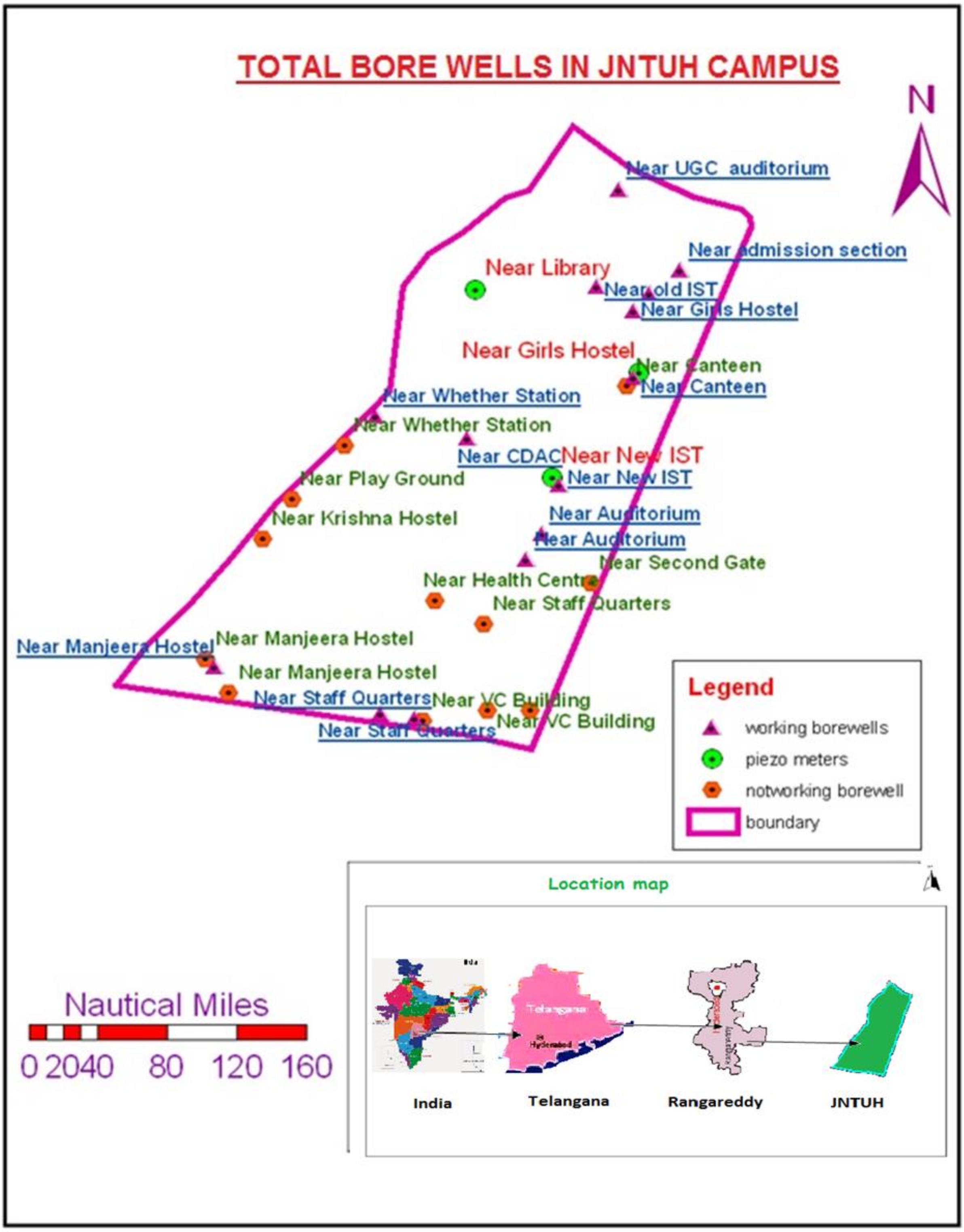
Demographic Profile of Kukatpally

Male	Female	Total	Scheduled caste			Tribal caste		
			Male	Female	Total	Male	Female	Total
166327	151018	317345	8894	8414	17308	1534	1431	2965

Source: Population Census - 2011.



Location of the Study Area at JNTUH Campus



Locations of the Total Bore wells in JNTUH Campus

List of the Bore Wells in JNTUH Campus

S.NO	PLACE	STATUS OF BORE WELL	NORTH	EAST
1	Near old IST	working	17º29'43.1"	78º23'32.9"
2	Near Library	**Piezometer**	17º29'41.3"	78º23'29.9"
3	Near UGC auditorium	working	17º29'47.4"	78º23'34.8"
4	Near admission section	working	17º29'43.4"	78º23'37.2"
5	Near Girls Hostel	working	17º29'42.9"	78º23'36.2"
6	Near Girls Hostel	**Piezometers**	17º29'39.5"	78º23'37.1"
7	Near Girls Hostel	working	17º29'38.9"	78º23'37.3"
8	Near Canteen	working	17º29'37.6"	78º23'36.9"
9	Near Canteen	Not working	17º29'37.4"	78º23'37.0"
10	Near New IST	**Piezometer**	17º29'33.6"	78º23'32.3"
11	Near New IST	Working	17º29'33.6"	78º23'32.3"
12	Near Auditorium	Working	17º29'30.4"	78º23'31.4"
13	Near Auditorium	Working	17º29'29.7"	78º23'31.3"
14	Near Second Gate	Not working	17º29'28.4"	78º23'33.3"
15	Near VC Building	Not working	17º29'23.6"	78º23'28.5"
16	Near VC Building	Not working	17º29'23.4"	78º23'27.7"
17	Near VC Building	Not working	17º29'27.3"	78º23'28.5"
18	Near Staff Quarters	Working	17º29'22.4"	78º23'25.7"
19	Near Staff Quarters	Working	17º29'22.9"	78º23'24.6"
20	Near Staff Quarters	Not working	17º29'23.3"	78º23'21.9"
21	Near Health Centre	Not working	17º29'28.2"	78º23'26.2"
22	Near Manjeera Hostel	Not working	17º29'25.1"	78º23'19.5"
23	Near Manjeera Hostel	Working	17º29'24.9"	78º23'16.0"
24	Near Manjeera Hostel	Not working	17º29'24.4"	78º23'16.4"
25	Near Krishna Hostel	Not working	17º29'30.1"	78º23'19.4"
26	Near Play Ground	Not working	17º29'33.3"	78º23'20.3"
27	Near Whether Station	Working	17º29'36.7"	78º23'23.2"
28	Near Whether Station	Not working	17º29'37.1"	78º23'23.9"
29	Near CDAC	Working	17º29'36.1"	78º23'29.0"

7.0 Methodology

Rainwater harvesting systems can be installed in both new and existing buildings and harvested rainwater used for different applications that do not require drinking water quality such as toilet flushing, garden watering, irrigation, cleaning and laundry washing. Harvested rainwater is also used in many parts of the world as a drinking water source. As rainwater is very soft there is also less consumption of washing and cleaning powder. With rainwater harvesting, the savings in potable water could amount up to 50% of the total household consumption. Several factors should be considered when selecting rainwater harvesting systems for domestic use:

- Type and size of catchment area
- Local rainfall data and weather patterns
- Family size
- Length of the drought period
- Alternative water sources
- Cost of the rainwater harvesting system.
- Rainfall amounts, intensities, and evapo-transpiration rates.

Although rainwater can be harvested from many surfaces, rooftop harvesting systems are most commonly used as the quality of harvested rainwater is usually clean following proper installation and maintenance. The effective roof area and the

material used in constructing the roof largely influence the efficiency of collection and the water quality. Rainwater harvesting systems generally consist of four basic elements:
(a) A collection (catchment) area
(b) A conveyance system consisting of pipes and gutters
(c) A storage facility
(d) A delivery system consisting of a tap or pump.

A collection or catchment system is generally a simple structure such as roofs and/or gutters that direct rainwater into the storage facility. Roofs are ideal as catchment areas as they easily collect large volumes of rainwater. The amount and quality of rainwater collected from a catchment area depends upon the rain intensity, roof surface area, type of roofing material and the surrounding environment. Roofs should be constructed of chemically inert materials such as wood, plastic, aluminum, or fiberglass. Roofing materials that are well suited include slates, clay tiles and concrete tiles. Galvanized corrugated iron and thatched roofs made from palm leaves are also suitable. Generally, unpainted and uncoated surface areas are most suitable. If paint is used, it should be non-toxic (no lead-based paints).

Conveyance system is required to transfer the rainwater from the roof catchment area to the storage system by connecting roof drains (drain pipes) and piping from the roof top to one or more downspouts that transport the rainwater through a filter system to the storage tanks. Materials suitable for the pipe work include polyethylene (PE), polypropylene (PP) or stainless steel. Before water is stored in a storage tank or cistern, and prior to use, it should be filtered to remove particles and debris. The choice of the filtering system depends on the construction conditions. Low-maintenance filters with a good filter output and high water flow should be preferred. “First flush” systems which filter out the first rain and diverts it away from the storage tank should be also installed. This will remove the contaminants in rainwater which are highest in the first rain shower.

Storage tank or cistern to store harvested rainwater for use when needed. Depending on the space available these tanks can be constructed above grade, partly underground, or below grade. They may be constructed as part of the building, or may be built as a separate unit located some distance away from the building. The storage tank should be also constructed of an inert material such as reinforced concrete, Ferro cement (reinforced steel and concrete), fiber glass, polyethylene, or stainless steel, or they could be made of wood, metal, or earth. The choice of material depends on local availability and affordability. Various types can be used including cylindrical Ferro cement tanks, mortar jars (large jar shaped vessels constructed from wire reinforced mortar) and single and battery (interconnected) tanks. Polyethylene tanks are the most common and easiest to clean and connect to the piping system. Storage tanks must be opaque to inhibit algal growth and should be located near to the supply and demand points to reduce the distance water is conveyed. Water flow into the storage tank or cistern is also decisive for the quality of the cistern water. Calm rainwater inlet will prevent the stirring up of the sediment. Upon leaving the cistern, the stored water is extracted from the cleanest part of the tank, just below the surface of the water, using a floating extraction filter. A sloping overflow trap is necessary to drain away any floating matter and to protect from sewer gases. Storage tanks should be also kept closed to prevent the entry of insects and other animals.

Delivery system which delivers rainwater and it usually includes a small pump, a pressure tank and a tap, if delivery by means of simple gravity on site is not feasible. Disinfection of the harvested rainwater, which includes filtration and/or ozone or UV disinfection, is necessary if rainwater is to be used as a potable water source.

The efficiency of rainwater harvesting depends on the materials used, design and construction, maintenance and the total amount of rainfall. A commonly used efficiency figure, runoff coefficient, which is the percentage of precipitation that appears as runoff, is 0.8. For comparison, if cement tiles are used as a roofing material, the year-round roof runoff coefficient is about 75%, whereas clay tiles collect usually less than 50% depending on the harvesting technology. Plastic and metal sheets are best with an efficiency of 80-90%. For effective operation of a rainwater harvesting system, a well designed and carefully constructed gutter system is also crucial. 90% or more of the rainwater collected on the roof will be drained to the storage tank if the gutter and down-pipe system is properly fitted and maintained. Common materials for gutters and down- pipes are metal and plastic, but also cement-based products, bamboo an wood can be used.

There are many factors that determine the total uantity of rainwater that can be harvested in a particular area and the system that would be appropriate for efficiently harvesting this quantity. Some of these are:

The total volume of rainwater available from any roof top surface is a product of total rainfall and the surface area of collection. A runoff coefficient is usually applied to account for infiltration, evaporation and other losses and it varies from 0.8 to 0.95.

Rainfall pattern as well as total rainfall, will often determine the feasibility of a rainwater harvesting system. In areas where rainfall occurs regularly in most parts throughout the year, implies that the storage requirement is low and hence the system cost will be correspondingly low and vice versa. Conversely, areas where total rainfall occurs during 1-2 months, the water collected during the monsoon has to be stored for use in remaining months throughout the year, which requires large storage structures as well as arrangement for some treatment.

The maximum intensity of rainfall will decide the peak flow, which is to be harvested, and depending upon the peak flow, the gutter size for sloping roof and diameter of drainage pipe has to be calculated.

For roof top rainwater harvesting, the collection area is restricted by the size of the roof of the dwelling unit. Sometimes other surfaces such as terrace, balconies and other projections are used to supplement the roof top collection area.

The storage tank is usually the most expensive component of rainwater harvesting system. Hence a careful analysis is required for design of storage tank capacity.

Assessment the site condition is the first step towards a sound system design. The five main site conditions to be assessed are:

a) Availability of suitable roof catchment,
b) Foundation characteristics of soil near the house,
c) Location of trees.
d) Estimated runoff to be captured per unit area of the roof, and
e) Availability and location of construction material.

The size of the catchment area and tank should be enough to supply sufficient water for the users during the dry period. Assuming a full tank at the beginning of the dry season (and knowing the average length of the dry season and the average water use), the volume of the tank can be calculated by the following formula:

$$V = t \times n \times q$$

Where

V = volume of tank, in liters;

t = length of the dry season (days);

n = number of people using the tank, and

q = consumption in liters per capita per day.

If, for example, 20 lpd (q) is agreed upon and a dry period of 100 days (t) is normally not exceeded, a storage volume of 10 m^3 would be required for a family of 5 members (n)

V =100 (t) x 5 (n) x 20 (q) = 10,000 liter or 10 m^3

The required catchment area (that is the area of the roof) can be determined by dividing the volume of the tank by the accumulated average rainfall volume (liter) per unit area (m^2) over the preceding wet months and multiplying this with the runoff coefficient, which varies from 0.8 to 0.95 depending upon type of roof.

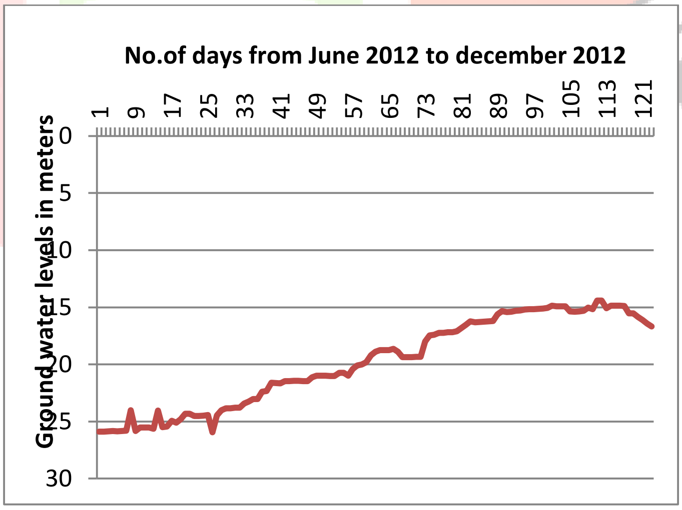
7.1 General Design Features

Roof top water harvesting systems can provide good quality potable water, if the design features outlined below are taken into account:

a) The substances that go into the making of the roof should be non toxic and chemically inert.
b) Roof surfaces should be smooth, hard and dense since they are easier to clean and are less likely to be damaged and release materials/fibers into the water.
c) Roof painting is not advisable ..
d) No overhanging trees should be left near the roof.
e) Nesting of birds on the roof should be prevented.
f) All gutter ends should be fitted with a wire mesh screen to keep out leaves, etc.
g) Appropriate arrangement for discarding the first flow of rainfall should be made.
h) A hygienic soak away channel should be built at water outlets and a screened overflow pipe should be provided.
i) The storage tank should have a tight fitting roof that excludes light, a manhole cover and a flushing pipe at the base of the tank (for standing tanks).
j) There should be a reliable sanitary extraction device such as a gravity tap or a hand pump to avoid contamination of the water in the tank.
k) There should be no possibility of contaminated wastewater flowing into the tank (especially for tanks installed at ground level).
l) Water from other sources, unless it is a reliable source, should not be emptied into the tank through pipe connections or the manhole cover.

JNTUH is located at 78º23'29.9"E longitude and 17º29'41.3"N latitude in Rangareddy district of Telangana. at an elevation of about 591 meters above the mean sea level. The average annual rainfall ranges between 100 mm to 200 mm. The average monthly rainfall data are being taken from the JNTUH Meteorological station Hyderabad..

Ground Water Level Fluctuations



Ground water Levels Fluctuations observed from ground level at IST Piezometers

Interpretation:

From the figure **it** is observed that Ground water levels are increased from 25.875m to 16.668 m. These levels are observed from the ground level. So total water level increased by 9.2 m, within duration of 123 days.

RWH PIT with Geo fabric membrane.

8.0 Results and Discussion

Within the JNTUH campus at Al,B1type Quarters, roof top harvested water can be determined. The water samples were collected Within the JNTUH campus from the all nine Bore wells. And all samples analyzed and their physical chemical characteristics , changes can be observed here.

The selected places are the best suitable for rain water collection, from each well the water sample is collected and analyzed their physical and chemical characteristics. The bore well location and well number is given in below table

Locations of Bore Wells along with IDs

S.NO.	Bore Well ID No	Location
1	A	Near EEE Building
2	B	Near EEE Building
3	C	Near EEE Building(PZ)
4	D	Near IST Building
5	E	Near IST Building
6	F	Near IST Building(PZ)
7	G	Near Girls Hostel(PZ)
8	H	Near Girls Hostel
9	I	Near Girls Hostel

Rain water Analysis Results

The samples were analyzed by the various parameters i.e., 1) Physical, 2) Chemical, 3) In organic . Analysis of sediment quality on various characteristics. The comparison of test results was done against WHO Standard values, which are furnished as here under. The samples are analyzed in the month of July 2012. The results are given in table

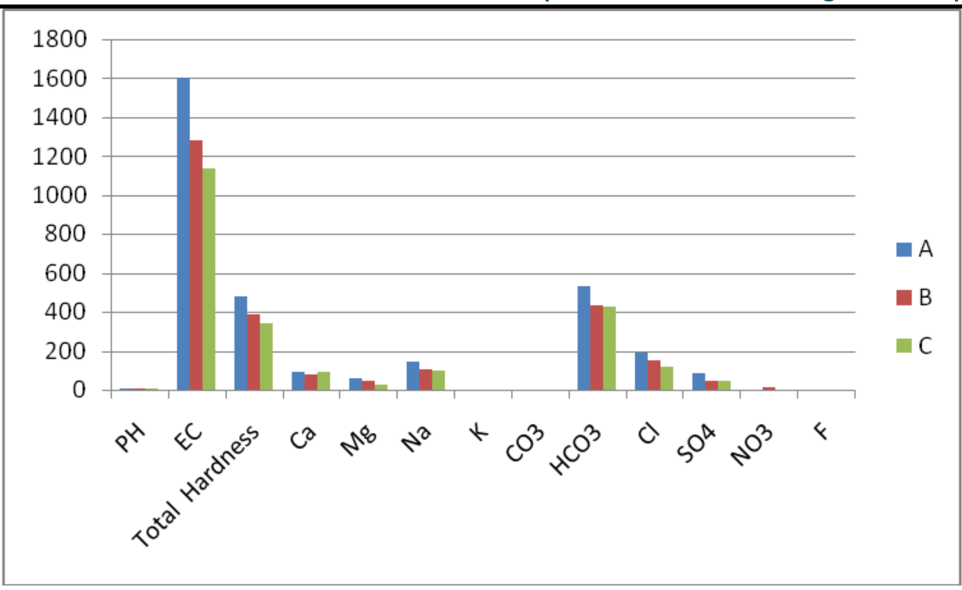
Bore well	PH	EC (dS/m)	Total Hardness (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	F mg/l)
A	7.05	836	178	60	6.7	111	0.98	1.0	393	53	0.5	29	1.1
B	7.15	1080	213	82	1.8	150	2.32	2.35	348	117	44	50	1.2
C	No Sample - dry												
D	6.96	868	245	75	14	87	1.51	1.6	372	85	0.2	24	1.5
E	7.13	1185	300	90	18	133	3.71	3.77	4.5	163	11	13	1.4
F	6.28	14.6	360	104	24	158	4.57	4.5	476	220	49	3.0	1.80
G	7.3	1315	100	28	7.3	253	7.29	7.2	427	184	27	22	1.0
H	7.43	1068	160	60	2.4	170	3.43	3.44	433	99	0.05	45	0.79
I	7.17	1063	220	84	2.4	142	2.87	2.9	403	99	0.5	80	0.77

Physical and Chemical Analysis of All Bore Wells Samples (July -2012)

Physical and Chemical Parameters of Ground water

ID No	Location	PH	EC (dS/m)	Total Hardness (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)
A	Near IST	6.50	1600	480	96	58	143	2.3	3.5	531	191	86	2.5
B	Near Girls Hostel	6.42	1280	390	80	46	108	2.0	4.5	433	149	48	14
C	Near Library	6.52	1140	345	92	28	101	3.1	2.0	427	117	48	3.7

Date of sample: December, 2012.



Water quality Parameters in three Bore wells

9.0 Conclusions:

This paper dealt with all aspect of improving the water scarcity problem in JNTUH campus by implementing ancient and old technique of rain water harvesting.

- The RWH structures existed in the campus, recharged an amount of 27,73,426 liters (with total roof area 3580 m² ,rainfall 774.7 mm)
- There is a lot of scope for further extension of the RWH project and can able to harvest more amount of water.
- JNTUH campus is located in the capital city Hyderabad, more visitors came and we demonstrated these structures. So they are the actual structures for the demonstration.
- Ground water levels are increased (we have taken daily ground water levels through observation wells).

The delineated study area is taken from Google map. Remote sensing, watershed modeling and GIS techniques are modern research tools that proved to be effective in mapping, investigation and modeling. These tools were used to determine the potential sites or areas for Rain Water Harvesting (RWH) in JNTU Hyderabad.

Based on ARC-GIS software and GPS techniques, these are the two major tools used to determine the potential areas for rainwater harvesting. For these facts and according to the overwhelming water crisis in JNTUH, RWH becomes an important alternative for providing water that could be valuable for implementing runoff farming and for multiple domestic purposes.

Rainwater harvesting recharge pits are constructed in various areas of JNTUH near Girls Hostel Building, IST building and library building with the capacity of 1, 00,000 liters by using two recharge shafts. Three Piezometers are drilled up to 100 ft for the purpose of the taking daily groundwater readings near Girls Hostel Building, IST Building and library building in JNTUH. The pH is important factor.

- The Bore wells having pH from 7 .05 to 7.43, so these wells water is neutral. Bore well E & F having 6.96 & 6.28. It is in slightly acidic nature.
- The Electrical Conductivity values are observed in all bore wells. The EC values lies between 836(dS/m**)** to1185 (dS/m).
- Hardness of the all samples values are between 100 and 360. This well below the W.H.O standard which ranges between (100-300 mg/l). And may also extend up to 600 mg/l as per the IS: 10500. The lowest total hardness is present in the G i.e. 100 mg/l and highest total hardness is present in the F bore well i.e. 360 mg/l.
- It was observe that the calcium available in the rain water was below the W.H.O standard for drinking which is (20-200 mg/l). Although, it has no side effect medically, the calcium should be increased to fall within the W.H.O standard for drinking water.
- The Magnesium values are observed between 1.8 mg/l to up to 7.3 mg/l, according to IS: 10500 the required limit of Magnesium is 0.1 mg/l and accessible limit is 0.3 mg/l. But all wells don't have the accessible limit values. For best domestic purposes treatment is required.
- The observed Sodium values lies between 78 mg/l to 228 mg/l. According to IS: 10500 sodium accessibility limits is 45 mg/l.
- The observed chlorine values are lies between 53 mg/l to 220 mg/l. According to IS: 10500 the Chlorine desirable limit is 250 ppm, May be extended up to 1000 ppm.
- The observed Sulphate value lies between the 0.2 mg/l and 49 mg/l. But according to the IS: 10500 standards the desirable limit is150 mg/l and it may be extended up to 400 mg/l.
- Nitrite concentrations in drinking water seldom exceed 0.1 mg/L. The U.S. Public Health Service has established 10 mg/l of nitrate-nitrogen as the maximum contamination level allowed in public drinking water. The Nitrate values are observed between 13 mg/l to up to 80 mg/l, according to IS: 10500 the required limit of NO_3 is 45 mg/l and accessible limit is 100 mg/l.
- The fluorine values are observed between 0.77 mg/l to 1.80 mg/l. According to ISO: 10500 accessibility limits is 0.6 to 1.2. If the limit is below 0.6 water should be rejected, Max. Limit is extended to 1.5.all the observed values are within the limits except F bore well.
- According to W.H.O, CPCB, APPCB, and IS: 10500 the above mentioned harvested water doesn't meet their permissible limit, so this water is not potable for drinking purposes and only useful for domestic purposes , gardening. By adapting different advanced treatment techniques water can be used for drinking purposes.

10.0 References

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