ARTIFICIAL GROUND WATER RECHARGE USING ROOFTOP RAINWATER HARVESTING SYSTEM

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Abstract

Artificial groundwater recharge can be considered as one of the appendage through which the water table level can be increased at a rate surpassing the augmentation rate under natural conditions of replenishment. While rainwater harvesting is simply the aggregation of raindrops. In this case a rooftop of a residential building was used for the purpose of artificial recharge. The rainwater is passed through gutters followed by first-flush device, filter unit and a storage tank from where excess water was diverted into a dry or non-working bore at a suitable infiltration rate, this is similar to depositing surplus money into a bank for future needs. This paper discusses the objectives, scope, methodology and the results obtained on this.

Key words: Artificial Recharge, Infiltration, Rainwater Harvesting, Bores, Runoff.

I. INTRODUCTION

1.0 Introduction

The scarceness of water is a well-known reality. Even though India has a higher average annual rainfall (1,170 mm) as compared to the global average (800 mm) it does not have sufficient water. Much of the precipitation falling on the paved surface tends to drain rapidly, leaving very little for the recharge of groundwater. Due to which, many parts of India experience lack of water. Open water rootage betray in meeting the increasing call for water supply; sub-surface stockpiles are being tapped and over-exploited leading to a turn down in groundwater levels and impairment of water table caliber. This unstable situation needs to be amended immediately by recharging the exhausted aquifers. Therefore, the call for carrying out the appraises to ensure that rain falling over a region especially on residential buildings is tapped as fully as possible through water harvesting, and there by recharging it into the groundwater formation

1.1 Objectives

The project has been carried out to determine the following:

1. To assist towards the water management and conservation there by enhancing the groundwater through capturing and stash away water harvested from rooftop run-off.
2. Decrease the practice of rainwater flow into drains during rains in residential buildings.
3. To use harvested rainwater instead of groundwater in daily works by building a storing tank to directly collect rainwater and then after proper, use the water in daily works.
4. Incorporating an economical first flush device and filter unit to make water usable.
5. To understate cost of exhausting storm water and get obviate water logging in the vicinity

1.2 Scope of the Project

It is necessary to carry out systematic study on the determination of the rainwater harvesting system and artificial ground water recharge in the residential areas, for better living standards. Since the water is becoming scarce day by day, it would be effective if suitable model / method is developed which will enable the better water usability close to the present day scenario. Keeping these in view, the problem is defined with the following scope.

a) To compute theoretically the amount of recharge into the ground water using the rainwater harvesting system that is in vogue.
b) To identify the particular method / equation that predicts the amount of water that can diverted from the drains to the recharge structure. This is accomplished through comparison of the theoretical rate with the values in the reference codebook.
c) To evaluate the possibility of the recharge system in a residential building.

1.3 Privileges of Rainwater Harvesting for Artificial Recharge of Ground Water

Following are the few main advantages in relation to this:

1. The handiness of groundwater can be heightened at any specific place and time thus assuring an uninterrupted and dependable approach to groundwater.
2. The runoff which chokes storm drains and forefends flooding's can be cuted down
3. Water requirement during summer and drought conditions can be self-relianced to water supply.
4. The rate of power consumption for pumping of groundwater can be brought down viz., for every 1 m rise in water level, there is a saving of 0.4 KWH of electricity. [12]
5. It Brings down soil erosion in populated area.
6. RWH is the best preferred source of water for domestic use, In Islands and in deserts. Also it is less pricey, easy to fabricate, operate and maintain.

1.4 Study Area

The study domain has been situated in Devuducheruvu of Mylavaram, which is an exciting G + one residential building with a concrete roofing of open area 150 sq.m. It is located in Mylavaram Mandal of Vijayawada revenue division. Mylavaram is located at 16.7833°N 80.6333°E. It has an average elevation of 47 meters (157 feet). The area lies in Krishna district, which is one of the prosperous and fertile coastal districts of Andhra Pradesh. The area is an upland part of the Krishna delta. It has scattered hill ranges of Eastern Ghats running in northeast south-west direction under Kondapalli and Konduru reserved forest zones.

The general clime of the area is blistering and humid. The somatic sensation ranges from 33° C maximum and 16° C minimum in the months of January and February to a 43°C maximum and 25° C minimum temperatures in April & May. The average annual rainfall ranges from 800 to 1500 mm, of which 70-75% is during June to September due to South-West monsoon. Whereas the rest 25-30% is during October to December due to the North-East monsoon.

Wind direction is predominant in South-East and East directions in the morning hours except in monsoon seasons when the predominant wind direction changes towards westwards. In the evening and night the ·predominant wind direction is southeast and south except in monsoon months when the direction changes towards west. The area has large number of water bodies, which count to about 40 both big and small. The water bodies, many of them dry up in the dry season. These are usually in the upland portion of the area.

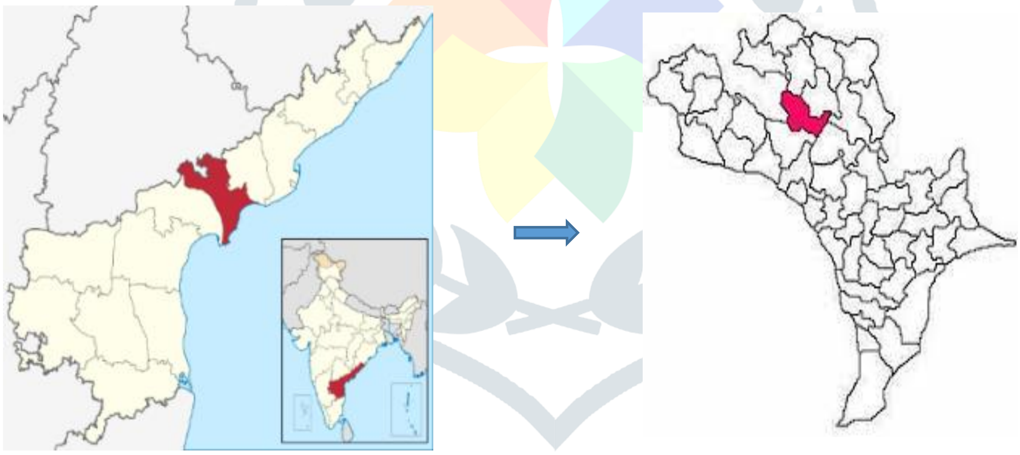

Fig.1.1 Study Area

II METHODOLOGY

2.1 Rainwater Harvesting System

The project lacks sufficient background, with reference to the existing data, the path was so divided to achieve the objectives in such a way keeping all the fundamentals System Components viz.,

A. Roof

The roof can be of many types here, the building has a roughly finished floor as catchment area. The dimensions of the roof top is 15m X 10m, making an open area of 150 sq. m (approx.). The roof was completely open without any trees covering over it. The height of parapet was 1.2m, thus, as per the IS 15747:2008 code for RWH system it is assumed that the total rainfall collecting efficiency to be 90% based on articles. The runoff coefficient considered was nearly 0.7 considering all the initial losses like evaporation, percolation, surface roughness etc.

B. Mesh/ Coarse Screen

It is used to hinder the large floating objects, leaves etc. to flow into gutter along with the rainwater. As the building being already constructed, a 20 number type course screen mesh of one unit was used.

C. Gutter and Down Pipes

Gutter is a collecting pan for rainwater from sloping roof to transfer it to downpipe. In this project, building no gutter is observed to be used. Down pipe transfers rainwater collected on the catchment to the storage via first flush device and the filter units sizing of it is observed to be of 3-inch dia, which reaches standards as specified in table of IS15747:2008

D. First Flush Unit

It is a device built sophistically to drain off the first/initial rainfall collected on roof to clean dirt which if incorporated in the house because the collected rainwater is just left to the drains. So for economy it was designed for 1m length thus total volume of waste water collected being equal to.,

$= \pi/4 * 0.1^2 * 1 * 1000 = 7.8$liters

E. Filter Unit

The objective of this project is to utilize the excess rainwater going to the drain, to recharge ground water. It is essential to make water silt free and purify to the optimist. Thus, VARUN type of filter is used, as it is very economical and feasible. For a 90liters capacity filter the head loss is less than 2cm and it needs a periodic inspection in every water year.

F. Storage

There are number of options for the construction of tanks keeping in view the shape, the size and the material of construction. A Ferro cement tank is proposed to be fabricate because of the following vantages:

a) Allay in finding structural problems/leaks,

b) Allay in maintaining and cleaning and

c) Allay to render water.

The tank is provided with pipe fixtures to render the water, to clean and dispose of the excess water.

G. Site Selection

From the layout of the building where, it can be viewed that a dry bore is at the corner. The bore was dugged upto 14m below ground level about 10 years back and it went dry nearly 3 years back. The soil strata over here is sandy silt type. Upon investigating few more working bores near the test bore, the water table is found to be at 18m below ground level. The dry bore used is of 15cm diameter upto top 1m and later on, it is 10cm upto 14m. This was because in the top 1m distance motor is usually fixed and later only pipe is laid bottom of the borehole for drawing and encasing.

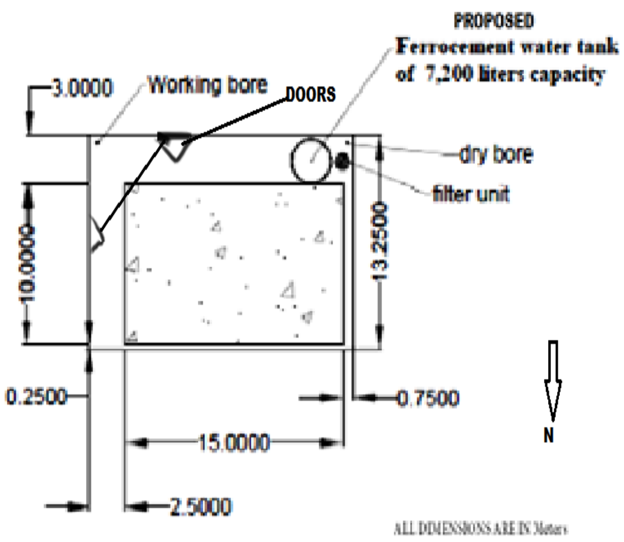

Fig 2.1: Layout of the Building

H. Determination of Rate of Recharge:

Artificial Recharge requires the rate of water percolation in the respective areas. As percolation gets influenced by various factors, Horton's, suggested an exponential relationship between seepage and time, which was characterized by the following equation

$$f_t = f_c + (f_o - f_c)$$

Where,

f_t = Infiltration at any time, t

f_c =Constant rate of infiltrartion

f_o =Initial rate of infiltrartion

Initially the water left/poured goes directly without any holding time but it gradually decreases and attains a constant rate after some time, which gives the average percolation rate of the soil. As the project needs recharge at the bottom of bore, adopting ordinary tests of infiltration to determine the percolation rate can be simply ruled out. Thus it demanded the adoption of PCM (Pulse Code Modulated) equipment, where it was considered that a 25cm interval depths and determined the time taken for each 25cm depth of water to fall. Using this data excel graph can be obtained which gives the data about the average percolation rate.

The following procedure was carried out to determine the recharge rate

Step 1) Finding the bore and measuring the depth and diameter

- Depth of the bore is determined using a rope which was thrown down by attaching weight at the end and found to be 14m
- Diameter of the bore 15cm upto 1m and later 10cm until 14m.

Step 2) Calculation of volume of the bore.

$V = \left\{ \left[\frac{\pi}{4} * 0.15^2 * 1\right] + \left[\frac{\pi}{4} * 0.1^2 * 13\right] \right\} * 100 = 120$ liters

Step 3) Installing the percolation rate-measuring device

Step 4) Filling up of the bore with water

- Velocity of filling 33cm/sec

Step 5) Measurement of the elapsed timings

Step 6) Continuing the process until the percolation rate is constant

Step 7) Termination and plot the graph

2.2 Artificial Ground Water Recharge System

The excogitation involves thoughtfulness of data on hydrological, hydrogeological aspects and hydro meteorological parameters. The background information collected is as given below:

a) Array contrive of the area.
b) Demarcation of the areas.
c) Portrayal of flow into storm water drains.
d) Particulars of the existing ground water abstraction structures in and around the vicinity of the project site.
e) Reckoning of the absquatulate rainfall.
f) Availability of space for building of recharge structures.

A. Recharge Structure

An existing tube well was applied as recharge structure. It was properly formulated in advance to use as recharge structure. PVC pipes of 3.94 inch diameter are positioned to roof drains to collect rainwater. The initial roof runoff is drained through first-flush devise. Rainwater from this is taken to collection desilting chamber/filter unit. .

IV. DISCUSSION ON RESULTS

A. Results Regarding Rainwater Harvesting System

The results obtained were as discussed below:

1. Determination of rainfall intensity:

Average rainfall from the past 30 years = 900.00mm (approx.)

Maximum rainfall intensity in this year (2017-2018) =50.7mm/day

2. Rainwater Harvesting potential:

RWH potential = Maximum Rainfall Intensity X Area of the Roof X Runoff Coefficient X Efficiency of Collection.

= (50.7/1000)*150*0.7*0.9 = 4.8cu.m

Adopting a Factor of Safety = 1.5*4.8cu.m

Therefore, the Storage provided=7.2cu.m (optimum)

3. Water demand:

Considering four occupants with an average water consumption rate of 200 LPCD,

The Water demand for a day = 4*(200/1000) = 0.8 cu.m

Adopting a Factor of Safety = 1.5*0.8 = 1.2 cu.m

Amount of Excess water = 7.2-1.2 = 5 cu.m

Therefore, dead storage of 1,200 litres is optimum and excess of water can be recharged. Per day by having a live storage.

4. Storage tank:

Due to space constraints, open space being 3m which can be viewed from the layout,

The outer to outer Tank diameter can be calculated as = 3-0.1-0.1=2.8m (assuming a 10cm free space)

Considering a Thickness of 5cm, now the inner free space is = 2.8-0.05-0.05=2.7m

Providing a chicken-mesh Reinforcement for the Ferro cement tank, the Height of the tank can be obtained as

$$7.2 = \frac{\pi}{4} * 2.7^2 * H$$

H=1.25m

Hence, it is economical to provide a cylindrical Ferro cement underground tank of capacity 7.2 cubic meter i.e. 7200 litters with a diameter of 2.7m and depth =1.26m with a dead storage of 1200 litters and providing diversion at a depth of 0.21m from bottom of the tank.

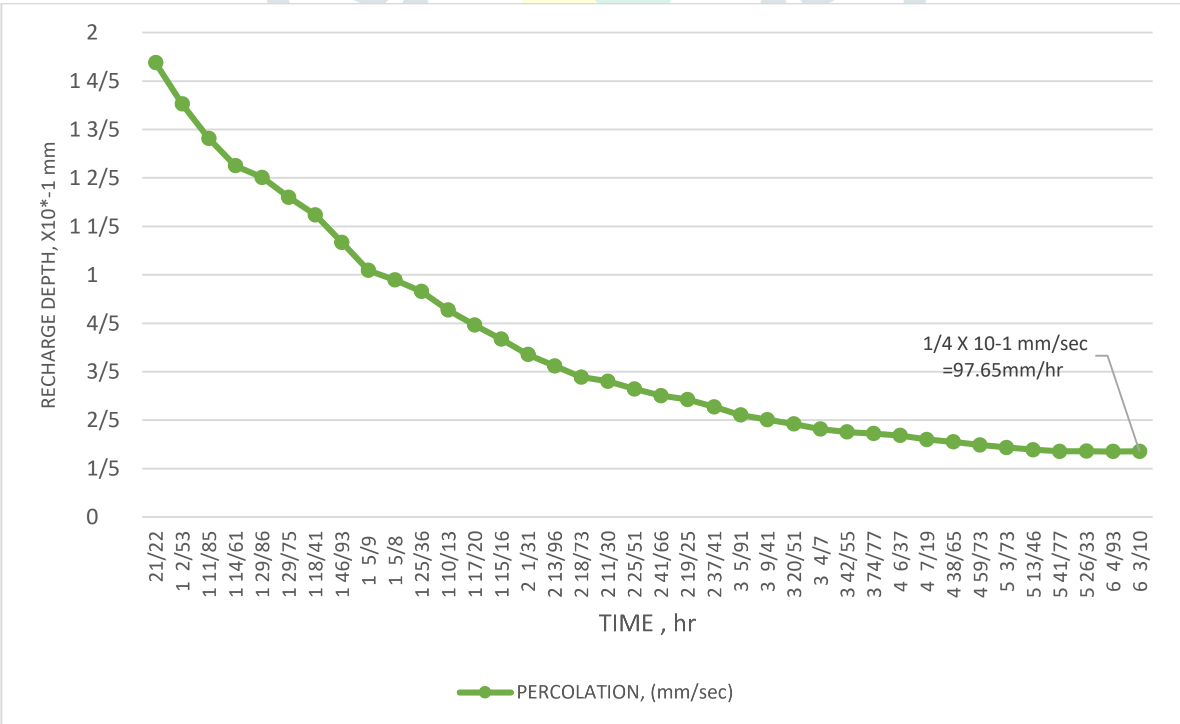

Fig 4.1 Recharge Rate in Bore (as per Horton's Graph)

B. Planning of Artificial Recharge Project

1) Area Identification

Every A.R project is field specific and even the repro of the techniques from similar areas are to be based on the local hydrogeological and hydrological environments. The major initial step is to delimitate the area of recharge. The A.R of ground water was called up due to the identification of the following problems:

1. The ground water levels are turning down on regular basis; this was studied because the bore, which was working for the past 10 years, was dried recently.
2. A substantive amount of aquifer has already been impregnated, as it can be seen by the phenomenon of deepening the bores.
3. The handiness of ground water is short in lean months. In Mylavaram, from April water crisis start and it reaches a peak during summer.

2) Scientific data

In order to contrive the A.R schemes following disciplines are needed
a) Hydro meteorological Studies
b) Hydrological Studies
c) Soil Infiltration Studies
d) Hydrogeological Studies
e) Aquifer Geometry
f) Geophysical Studies
g) Chemical Quality of Source Water
h) Clogging of soil due to Suspended matter

E. Costing

The major constituents of any RWHs which are readily available naturally are rain and catchment area. the pipe connections require little bit of capital. while fixing up the slopes of roofs and location of rainwater outlets needs some care. Even then, the capital investment varies largely depending on the availability of existing structures like wells and tanks, which can be altered for water harvesting.

Usually, installation of a water harvesting system in a project costs between Rs 2K to 30K for an edifice of about 200 m^2 (for an existing building). In the following table gives some basic rates of construction activities and materials. which is not comprehensive and contains only important activities meant to provide a rough estimate of the cost.

Table 4.1 some basic rates of construction activities and materials

S.No	Material	Size	Rate (Rs.)
1.	Water Pipe HDPE/PVC	50 To 150 Mm Dia Pipe	15 To 30 (Running Feet)
2.	PVC Tank	1000liters	2.55 Per Litre
3.	Ferrocement Tank	5000liters	250 Per Litre
4.	Elbows And Tees	--	20 To 75
5.	Filter Drum	--	700
6.	Filter Material	--	1500
7.	First Flush	50 Litters	750
8.	Motor Pump	0.5 H.P	1800
		1 H.P	3500

V CONCLUSION

The study carried out has resulted in a number of conclusions of which the most important ones are listed below.

1) The use of this saved water instead of groundwater in daily works by building a storing tank is proved to be economical and feasible.
2) The first flush device and filter can be easily made insitu using the locally available materials and it was observed that it cleans and drains the initial dirty water effectively with less water wastage.
3) The overall cost of the RWH System and the AR system combined comes to be nearly Rs.30,000. The major cost expenditures are Storage tank, pipes filter unit and first flush devices. Also the return period for investment is less.
4) The project is easily adaptable in households as it does not require any skilled workforce, also it can be implemented to existing or even to the new buildings.
5) Since, the source water being utilized is rainwater, which is one of the purest form of water also the filtration and purification processes are coming cheap, very or no pollution is being added upto the groundwater.
6) The system provides an option of storing and recharging thus on large scale say, municipality the demand for municipal water decreases and also as the waste rainwater collecting in drains decrease, cost of sewage treatment also decreases.
7) The system stores water in tanks and recharges it through closed systems thus chances of flies and mosquitoes breeding is decreased.

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