HYBRID APPROACH IN RAIN WATER HARVESTING TECHNIQUE FOR ENHANCEMENT OF GROUND WATER USING GEOMEMBRANE AND GEOFABRIC MEMBRANE

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Abstract - Water scarcity problem is global issue observed both in urban and rural areas. India is also facing water scarcity due to uneven distribution of rainfall, unsuitable geology as well as geography. To overcome this problem government of India has invested much funds and efforts. The aim of the present study is to design and implement rain water harvesting technique for ground water recharge and quality improvement by using geofabric and geomembrane. Implementation of technique is in study area which is located at Chinchawali, Raigad (M.S.) India. The geological investigation of study area shows that geology doesn't allows water to recharge aquifer therefore ground water availability is not perennial. The study also evaluated that the quality aspects of well water not go with World Health Organization standard's for drinking water. So, by implementing of rainwater harvesting technique we are expecting constructive progress in ground water quantity and quality as per our analysis.

Keywords- Geomembrane, Geofabric membrane, design and estimation.

I. INTRODUCTION

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams. The techniques usually found in Asia and Africa arise from practices employed by ancient civilizations within these regions and still serve as a major source of drinking water supply in rural areas. Commonly used systems are constructed of three principal components; namely, the catchment area, the collection device, and the conveyance system.

A) Catchment Areas

Rooftop catchments: In the most basic form of this technology, rainwater is collected in simple vessels at the edge of the roof. Variations on this basic approach include collection of rainwater in gutters which drain to the collection vessel through down-pipes constructed for this purpose, and/or the diversion of rainwater from the gutters to containers for settling particulates before being conveyed to the storage container for the domestic use. As the rooftop is the main catchment area, the amount and quality of rainwater collected depends on the area and type of roofing material. Reasonably pure rainwater can be collected from roofs constructed with galvanized corrugated iron, aluminum or asbestos cement sheets, tiles and slates, although thatched roofs tied with bamboo gutters and laid in proper slopes can produce almost the same amount of runoff less expensively (Gould, 1992). However, the bamboo roofs are least suitable because of possible health hazards. Similarly, roofs with metallic paint or other coatings are not recommended as they may impart tastes or colour to the collected water. Roof catchments should also be cleaned regularly to remove dust, leaves and bird droppings so as to maintain the quality of the product water (see figure 1).

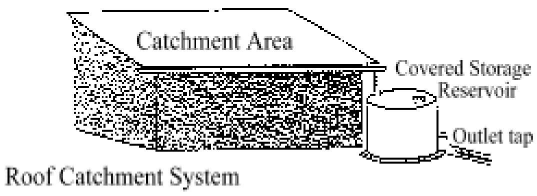

Figure 1: Rooftop Catchment System.

Land surface catchments: Rainwater harvesting using ground or land surface catchment areas is less complex way of collecting rainwater. It involves improving runoff capacity of the land surface through various techniques including collection of runoffs with drain pipes and storage of collected water. Compared to rooftop catchment techniques, ground catchment techniques provide more opportunity for collecting water from a larger surface area. By retaining the flows (including flood flows) of small creeks and streams in small storage reservoirs (on surface or underground) created by low cost (e.g., earthen) dams, this technology can meet water demands during dry periods. There is a possibility of high rates of water loss due to infiltration into the ground, and, because of the often-marginal quality of the water collected, this technique is mainly suitable for storing water for agricultural purposes. Various techniques available for increasing the runoff within ground catchment areas involve: i) clearing or altering vegetation cover, ii) increasing the land slope with artificial ground cover, and iii) reducing soil permeability by the soil compaction and application of chemicals (see figure 2)

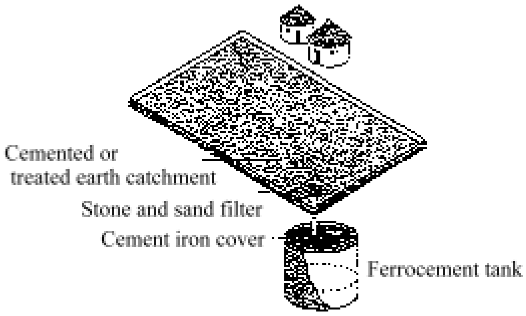

Figure 2: Ground Catchment System

Clearing or altering vegetation cover: Clearing vegetation from the ground can increase surface runoff but also can induce more soil erosion. Use of dense vegetation cover such as grass is usually suggested as it helps to both maintain a high rate of runoff and minimize soil erosion.

Increasing slope: Steeper slopes can allow rapid runoff of rainfall to the collector. However, the rate of runoff must be controlled to minimize soil erosion from the catchment field. Use of plastic sheets, asphalt or tiles along with slope can further increase efficiency by reducing both evaporative losses and soil erosion. The use of flat sheets of galvanized iron with timber frames to prevent corrosion was recommended and constructed in the State of Victoria, Australia, about 65 years ago (Kenyon, 1929; cited in UNEP, 1982).

Soil compaction by physical means: This involves smoothing and compacting of soil surface using equipment such as graders and rollers. To increase the surface runoff and minimize soil erosion rates, conservation bench terraces are constructed along a slope perpendicular to runoff flow. The bench terraces are separated by the sloping collectors and provision is made for distributing the runoff evenly across the field strips as sheet flow. Excess flows are routed to a lower collector and stored (UNEP, 1982).

Soil compaction by chemical treatments: In addition to clearing, shaping and compacting a catchment area, chemical applications with such soil treatments as sodium can significantly reduce the soil permeability. Use of aqueous solutions of a silicone-water repellent is another technique for enhancing soil compaction technologies. Though soil permeability can be reduced through chemical treatments, soil compaction can induce greater rates of soil erosion and may be expensive. Use of sodium-based chemicals may increase the salt content in the collected water, which may not be suitable both for drinking and irrigation purposes.

B) Collection Devices

Storage tanks: Storage tanks for collecting rainwater harvested using guttering may be either above or below the ground. Precautions required in the use of storage tanks include provision of an adequate enclosure to minimize contamination from human, animal or other environmental contaminants, and a tight cover to prevent algal growth and the breeding of mosquitos. Open containers are not recommended for collecting water for drinking purposes. Various types of rainwater storage facilities can be found in practice. Among them are cylindrical ferrocement tanks and mortar jars. The ferrocement tank consists of a lightly reinforced concrete base on which is erected a circular vertical cylinder with a 10 mm steel base. This cylinder is further wrapped in two layers of light wire mesh to form the frame of the tank. Mortar jars are large jar shaped vessels constructed from wire reinforced mortar. The storage capacity needed should be calculated to take into consideration the length of any dry spells, the amount of rainfall, and the per capita water consumption rate. In most of the Asian countries, the winter months are dry, sometimes for weeks on end, and the annual average rainfall can occur within just a few days. In such circumstances, the storage capacity should be large enough to cover the demands of two to three weeks. For example, a three-person household should have a minimum capacity of 3 (Persons) x 90 (l) x 20 (days) = 5 400 l.

Rainfall water containers: As an alternative to storage tanks, battery tanks (i.e., interconnected tanks) made of pottery, ferrocement, or polyethylene may be suitable. The polyethylene tanks are compact but have a large storage capacity (ca. 1 000 to 2 000 l), are easy to clean and have many openings which can be fitted with fittings for connecting pipes. In Asia, jars made of earthen materials or ferrocement tanks are commonly used. During the 1980s, the use of rainwater catchment technologies, especially roof catchment systems, expanded rapidly in several regions, including Thailand where more than ten million 2 m3 ferrocement rainwater jars were built and many tens of thousands of larger ferrocement tanks were constructed between 1991 and 1993. Early problems with the jar design were quickly addressed by including a metal cover using readily available, standard brass fixtures. The immense success of the jar programmed springs from the fact that the technology met a real need, was affordable, and invited community participation. The programmed also captured the imagination and support of not only the citizens, but also of government at both local and national levels as well as community-based organizations, small-scale enterprises and donor agencies. The introduction and rapid promotion of Bamboo reinforced tanks, however, was less successful because the bamboo was attacked by termites, bacteria and fungus. More than 50 000 tanks were built between 1986 and 1993 (mainly in Thailand and Indonesia) before a number started to fail, and, by the late 1980s, the bamboo reinforced tank design, which had promised to provide an excellent low-cost alternative to ferrocement tanks, had to be abandoned.

Conveyance systems are required to transfer the rainwater collected on the rooftops to the storage tanks. This is usually accomplished by making connections to one or more down-pipes connected to the rooftop gutters. When selecting a conveyance system, consideration should be given to the fact that, when it first starts to rain, dirt and debris from the rooftop and gutters will be washed into the down-pipe. Thus, the relatively clean water will only be available some time later in the storm. There are several possible choices to selectively collect clean water for the storage tanks. The most common is the down-pipe flap. With this flap it is possible to direct the first flush of water flow through the down-pipe, while later rainfall is diverted into a storage tank. When it starts to rain, the flap is left in the closed position, directing water to the down-pipe, and, later, opened when relatively clean water can be collected. A great disadvantage of using this type of conveyance control system is the necessity to observe the runoff quality and manually operate the flap. An alternative approach would be to automate the opening of the flap as described below.

A funnel-shaped insert is integrated into the down-pipe system. Because the upper edge of the funnel is not in direct contact with the sides of the down-pipe, and a small gap exists between the down-pipe walls and the funnel, water is free to flow both around the funnel and through the funnel. When it first starts to rain, the volume of water passing down the pipe is small, and the *dirty* water runs down the walls of the pipe, around the funnel and is discharged to the ground as is normally the case with rainwater guttering. However, as the rainfall continues, the volume of water increases and *clean* water fills the down-pipe. At this higher volume, the funnel collects the clean water and redirects it to a storage tank. The pipes used for the collection of rainwater, wherever possible, should be made of plastic, PVC or other inert substance, as the pH of rainwater can be low (acidic) and could cause corrosion, and mobilization of metals, in metal pipes.

In order to safely fill a rainwater storage tank, it is necessary to make sure that excess water can overflow, and that blockages in the pipes or dirt in the water do not cause damage or contamination of the water supply. The design of the funnel system, with the drain-pipe being larger than the rainwater tank feed-pipe, helps to ensure that the water supply is protected by allowing excess water to bypass the storage tank. A modification of this design is shown in Figure 5, which illustrates a simple overflow/bypass system. In this system, it also is possible to fill the tank from a municipal drinking water source, so that even during a prolonged drought the tank can be kept full. Care should be taken, however, to ensure that rainwater does not enter the drinking water distribution system.

II. STUDY AREA

The campus of zillah parishad primary school (2), Chinchawali, is situated at18º09´06.9´´N latitudes and 73º18´10.2´´E longitudes and is in the Konkan region of Maharashtra.

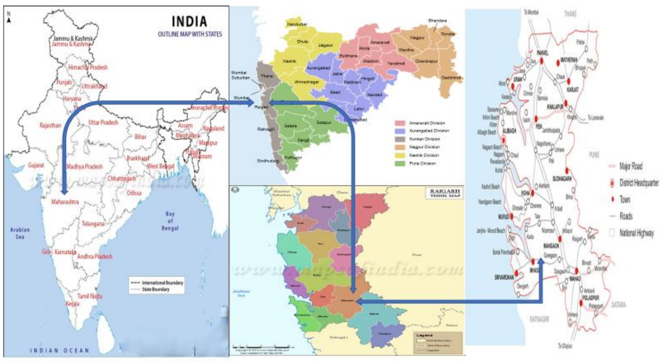

Figure 3: Study area of chinchawali school campus

The Description of the Study Area :

The study area is situated at the near by goregaon city in Raigad District. The institute is at centre of the campus and surrounded by agricultural area.The total strength of campus including students and staff peoples is more 1000. Thus, with this present strength and also with the expansion, campus should also increase its facilities and maintenance requirements. Thus water is most natural resource being always in high demands by human beings and is indispensable part of the life. Hence, keeping in view all the above problems and status of campus ZPCPS chinchawali, Raigad district, administrative body focussed on water scarcity problem. Therefore, in this situation, rain water harvesting system can be considered as a best solution for fighting against water scarcity in campus.

III. METHODOLOGY

A. General considerations: -

The average annual rainfall of the study area is 3303 for year 2018 with the help of map showing average annual rainfall for Konkan (Raigad) region. The life of rainwater harvesting system is considered as 50 years. The life of geomembrane and geofabric membrane is considered as 100 years and 10 years respectively. Runoff coefficient is considered 0.85

B. Catchment area: -

Catchment area for rainwater harvesting is obtained from rooftop of school building, kitchen and toilet.

Table 1: Catchment area calculation

Sr no.	Name	Area (in m^2)	Height (in m)
1	School building	63.9	3.75
2	Kitchen	14.51	2.30
3	Gents toilet	11.10	2.00
4	Ladies toilet	7.25	2.00

Total catchment area is 96.882m^2

C. Planning: -

It is the art of maintaining the all activities as per schedule of preparing activity like as designing, construction, maintenance of all over activities which is taken by hand.

D. Survey: -

It is the first essential step of any work which is carried out as per schedule within given time. It helps to know the actual condition of that catchment area and gives the proper solution over of them. It will be done by two various stages like as, preliminary survey and detailed survey.

Here, as per our project terms and conditions we will done levelling survey by using dumpy level instrument to find the actual level of that ground which is present inside of catchment area.by using dumpy level first find the back sight reading of that center point with the help of fixed reduce level. then we need to find intermediate readings after that fore sight readings are captured then by using Hight of instrument method or rise and fall method we find out the simple check of that ground slope to convey rain water which is collected in conduits.

E. Software: -

It is one of the modern techniques which useful for maintaining high accuracy in the work with reducing the time for preparing it through manual.

Here, we will use Auto-CAD software for drawing the all over layout plan, sections of that recharge pit with suitable scale.

F. Material: -

Gutter-

Gutter is required to be used for collecting water from sloping roof and to divert it to downspout. These are the channels all around the edge of a sloping roof to collect and transport rain water to the storage tank. Gutters can be of semi-circular, rectangular or trapezoidal shape. Gutters must be properly sized, sloped and installed in order to maximize the quantity of harvested rain. Gutter can be made using any of the following materials:

Galvanized iron sheet, Aluminium sheet, Semi-circular gutters of PVC material which can be readily prepared by cutting these pipes into two equal semi-circular channels, Bamboo or betel trunks cut vertically in half (for low cost housing projects)

The size of the gutter should be according to the flow during the highest intensity rain. The capacity of the gutters should be 10 to 15% higher. The gutters should be supported properly so that they do not sag or fall off when loaded with water. The connection of gutters and down spouts should be done very carefully to avoid any leakage of water and to maximize the yield. For jointing of gutters, the lead-based materials should not be used, as it will affect the quality of water.

Down Spout / Conduit

The rain water collected on the roof top is transported down to storage facility through down spouts / conduits. Conduits can be of any material like PVC, GI or cast iron. The conduits should be free of lead and any other treatment which could Contaminate the water. Table 2.1 gives an idea about the diameter of pipe required for draining out rain water based on rainfall intensity and roof area.

Filter

If the collected water from roof top is to be used for human consumption directly, a filter unit is required to be. If the collected water from roof top is to be used for human consumption directly, a filter unit is required to be installed in rainwater harvesting system before storage tank. The filter is used to remove suspended pollutants from rain water collected over roof. The filter unit is basically a chamber filled with filtering media such as fiber, coarse sand and gravel layers to remove. Debris and dirt from water before it enters the storage tank. The filter unit should be placed after first flush device but before storage tank. There are various types of filters which have been developed all over the country. The type and selection of filters is governed by the final use of harvested rain water and economy. Depending upon the filtering media used and its arrangements, various types of filters available are described below.

Sand filter

In the sand filters, the main filtering media is commonly available sand sandwiched between two layers of gravels. The filter can be constructed in a galvanized iron or Ferro cement tank. This is a simple type of filter which is easy to construct and maintain. The sand fillers are very effective in removing turbidity, colour and microorganism. In a simple sand filter that can be constructed domestically, filter media are placed. Easy to construct and inexpensive Filters can be employed for treatment of water to effectively remove turbidity (suspended particles like silt and clay), colour and microorganisms. In a simple sand filter that can be constructed domestically, the top layer comprises coarse sand followed by a 5-10 mm layer of gravel followed by another 5-25 cm layer of gravel.

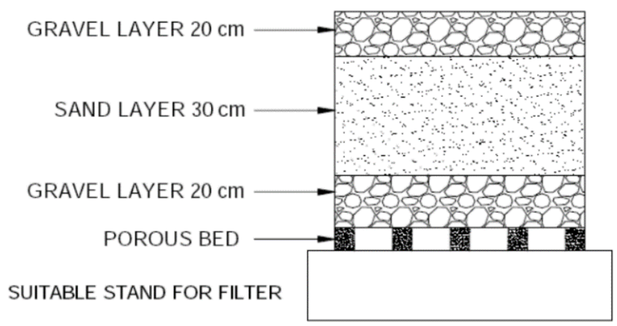

Figure 4: Sand filter

Charcoal water filter

This is almost like sand filter except that a 10-15 cm thick charcoal layer placed above the sand layer. Charcoal layer inside the filter result into better filtration and purification of water.

Sr. No.	B. S.	I. S.	F. S.	Remark
1	2.21			B. M.
2		1.45		A
3		1.35		B
4		1.24		C
5		1.49		D
6		1.54		E
7		1.6		F
8			1.68	Last Point

A proportionate layer of Gravel + Charcoal + Sand + Gravel, are used as filter.

The commonly used charcoal water filter is shown in

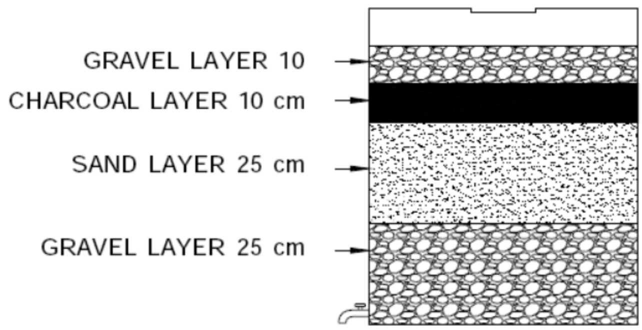

Figure 5: Charcoal water filter

Geomembrane

A geomembrane is very low permeability synthetic membrane liner or barrier used with any geotechnical engineering related material so as to control fluid (or gas) migration in a human-made project, structure, or system. Geomembranes are made from relatively thin continuous polymeric sheets, but they can also be made from the impregnation of geotextiles with asphalt, elastomer or polymer sprays, or as multilayered bitumen recomposites. Continuous polymer sheet geomembranes are, by far, the most common.

Geo fabric Membrane

Geotextiles are permeable fabrics which, when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain. Typically made from polypropylene or polyester, geotextile fabrics come in three basic forms: woven (resembling mail bag sacking), needle punched (resembling felt), or heat bonded (resembling ironed felt).

Geotextile composites have been introduced and products such as geogrids and meshes have been developed. Geotextiles are able to withstand many things, are durable, and are able to soften a fall if someone falls down.

G. Water treatment: -

All over water treatment activities will be done based on the world health organization's instruction with help of zeal water treatment plant.

In which we will collect the sample of various places which are available in the study area after that all over treatment like as hardness, turbidity, pH value, colour, odour test, chloride content, alkalinity ETC. are done with the help of zeal water treatment plant staff.

IV. RESULT AND DISCUSSIONS

The result of analysis shows that,

A) Levelling: -

Table 2: Readings of levelling

Sr. No.	B. S.	I. S.	F. S.	Rise	Fall	R. L.(m)	Remark
1	2.21					100.00	B. M.
2		1.45		0.76		100.76	A
3		1.35		0.10		100.86	B
4		1.24		0.11		100.97	C
5		1.49			0.25	100.72	D
6		1.54			0.05	100.67	E
7		1.60			0.06	100.61	F
8			1.68		0.08	100.53	Last Point

Table 3: Rise and fall calculation

Calculation check: -
Total Rise - Total Fall = Last R. L. – First R. L.
(0.76+0.10+0.11) - (0.25+0.05+0.06+0.08) = 100.53 – 100.00
0.53 = 0.53

B) Water testing: -

Sr.no.	Test	Permissible limit	Result well-1	Result well-2
1	Colour	<2 units	<5 units	<2 units
2	Odour	Agreeable	Disagreeable	Disagreeable
3	Taste	Agreeable	Agreeable	Agreeable
4	PH	6.5 to 8.5	6.5	6.6
5	Turbidity	Max.2 NTU	7.6 NTU	3.6 NTU
6	Hardness	120 mg/lit.	106 mg/lit.	174 mg/lit.

Table 4: Four hourly tests

SR.NO.	Test	Permissible limit	Result well-1	Result well-2
1	Chloride	Max. 200 mg/lit.	104.96 mg/lit.	98.96 mg/lit.
2	Sulphate	Max. 200 mg/lit.	16.85 mg/lit.	14.78 mg/lit.
3	Alkalinity	Max .200 mg/lit.	114 mg/lit.	154 mg/lit.
4	TDS	Max. 500 mg/lit.	107 mg/lit.	166 mg/lit.
5	RFC	0.2 mg/lit.	0.6 mg/lit.	0.5 mg/lit.

Table 5: Daily test

Sr.no.	Test	Permissible limit	Result well-1	Result well-2
1	Magnesium	Max. 30 mg/lit.	8.8 mg/lit.	6.6 mg/lit.
2	Calcium	Max. 75 mg/lit.	38.46 mg/lit.	36.56 mg/lit
3	Barium	Max. 1 mg/lit.	0.7 mg/lit.	0.6 mg/lit.
4	Copper	Max. 0.05 mg/lit.	0.5 mg/lit.	25.06 mg/lit.
5	Iron	Max. 0.1 mg/lit.	Nil	Nil
6	Nitrate	Max. 45 mg/lit.	25 mg/lit.	25.06 mg/lit.

Table 6: Weekly test

E) Design: -

Now, by using rational formula,
Q = C.I.A /3.6
Q= (0.85 x 3.303 x 96.76) ÷ 3.6
Q = 75.4607m^3/sec
Total runoff = 75460.7 lit./year

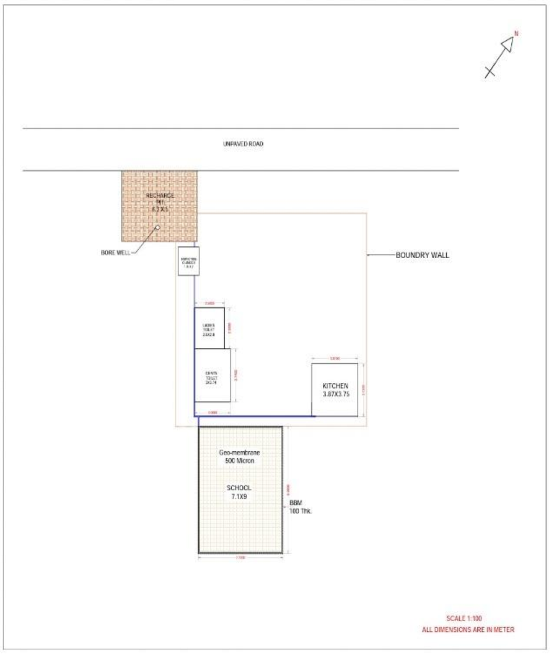

Figure 6: plan of study area showing pipes and gutters

ITEM No.	ITEM	QUANTITY	RATE[Rs.]	TOTAL COST(Rs.)
1.	**Excavation**	80.95 m^3 cu.m.(Min.2 Hr. Work By JCB)	1000/Hr.	2000
2.	**Material**			
I)	Pipe (5inch.Dia.)	30m	125/m	3750
II)	Gutter (6inch.Dia.)	11m	125/m	1365
III)	Elbow	9 No's	75/no's	675
IV)	T-Section	2 No's	150no's	300
V)	Geomembrane(500micron) Geofabric membrane(1000micron)	170m^2 12m^2	100/m^2 40/m^2	17000 480
VI)	Cement	6 bags	300/bags	1800
VII)	Sand	0.5m^3	1500/m^3	750
VIII)	Coarse Aggregate(40mm,20mm,10mm)	0.9m^3	750/m^3	700
IX)	Bricks	1150 no's	5/no's	5750
X)	Steel	20kg	35/kg	700
XI)	Charcoal	5.65m^3	30.60/kg	300
3.	**Labour**			
I)	Mason	2 No's	334/no's	868
II)	Mazdoor	8 No's	347no's	2776
III)	Bhisti	2 No's	327no's	654
		Total Estimated Cost: -		**39868/-**

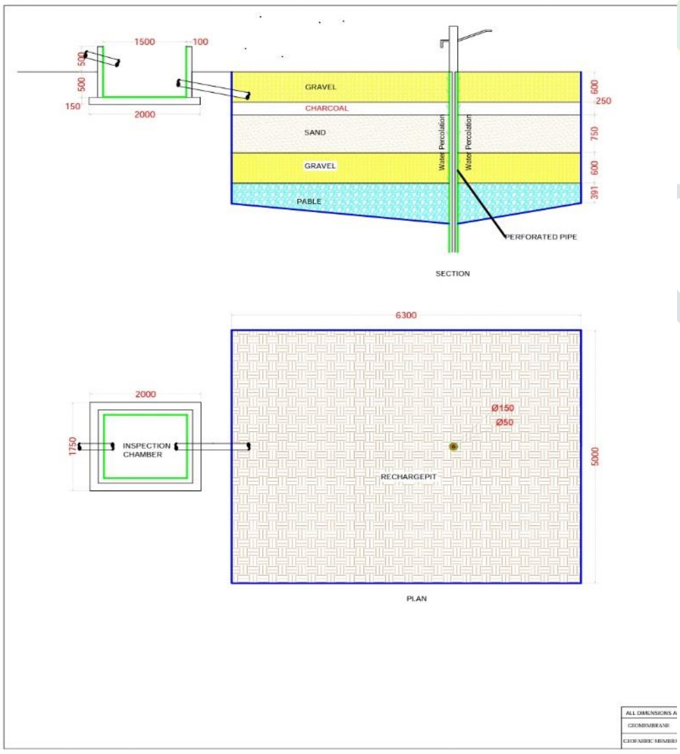

Figure 7: Plan and section of inspection chamber and recharge pit

ESTIMATION AND COSTING OF RECHARGE PITS:

The present rainwater harvesting system is having the storage of 75460.7 lit./year. The total cost of construction is Rs.39868

V. CONCLUSION

The conventional water sources namely well, river, reservoirs, etc. are inadequate to fulfill water demand due to unbalanced rainfall but we can solve this problem by rainwater harvesting technique. It was found that most of harvested and stored rain water could be utilize not only in rainy season but also over the whole dry periods of the year for the study area. Peoples thing about rainwater that it contains pollutants the truth is that rain water is extremely clean and safe if the location is in rural area where highway traffic and organization are far reaching so, in such area if rainwater is collected and stored in a proper and scientific manner management of water resources would enter a new era. Geomembrane is easily available, cheap and can be effectively used to solve water leakage problem during rainy season. The water of study area is not feasible for drinking, but it can be made feasible for drinking by using Geofabric membrane.

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