# Rainwater Harvesting – Technique to overcome the overall domestic water scarcity of Delhi

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**Abstract**— The necessity of useable water in India has put forth, the realization, that the water scarcity can be overcome by adapting ancient technology based reservoirs. It also comprises of natural water storage facilities. In order to reduce over-draft, conserve surface runoff and increase available ground water supplies, storage of water in reservoirs along with suitable recharge techniques has to be adapted. Recharge may be incidental, when it is a by-product of normal land and water utilization measures; and planned when the work is carried out with the sole objective of augmenting ground water storage to improve water availability or water quality, reduce impact of floods or preventing/stopping sea water intrusion. In order to increase the ground water availability, rainwater from rooftops would serve the best option that is easily available and can be conveniently adapted.

**Keywords**— Rainwater Harvesting, Overhead tank, Underground tank, Limestone, Ground water table, Ground tank, Open land rainwater harvesting

## INTRODUCTION

Water harvesting process has been in use and demand since ancient period. Plenty of open lands were available for these purposes during that time. However, in the present day scenario, there is scarcity of available free space in most towns and cities. Hence rainwater harvesting is the easiest and cost-effective process to overcome the scarcity of drinking and/or useable water. An arbitrary roof slab of dimensions $20m \times 15m$ along with the climatic conditions of Delhi has been chosen for this case study.

## CASE-STUDY

### *A. Rooftop rainwater harvesting*

Process of harvesting the rainwater, i.e., collecting at the time of rain, storing and using in its original form or after its filtration is called rainwater harvesting. If the catchment area is the roof of the house then it's called rooftop rain water harvesting. Due to depletion of underground water table, people face scarcity of water (even drinking water) in their day-to-day lives. The rainfall pattern is also unreliable in most of the regions. Increasing pollution in present world increases the difficulty to achieve pure form of water. Water bodies are getting drier due to global warming. Without any continuous input in form of materials, cleaning of apparatus, or any form of filtration equipment, we can overcome this difficulty by using rainwater harvesting technique.

### *B. Open-land Rainwater Harvesting*

In those regions where construction is not done i.e. open space area, most part of the rainwater gets wasted in the form of runoff and evaporation. To deal with this situation, designing of rainwater harvesting in such areas should be in such a way that losses are minimized effectively. For this issue the agricultural lands (as agricultural lands serve to be majority of such open-land areas) should be leveled in such a way that all the rainwater would flow through the desired route and it would collect in a tank or would be flown into a bore-well.

### *C. Rainfall Data*

As we are considering the overall land space of Delhi, that includes occupied as well as non occupied zones, a catchment area of dimensions $20m \times 15m$ has been arbitrarily taken for our case study. We have also considered the climatic conditions of Delhi which has an annual rainfall of about 0.715m. In our project we would collect the rain water in the catchment area mentioned above.

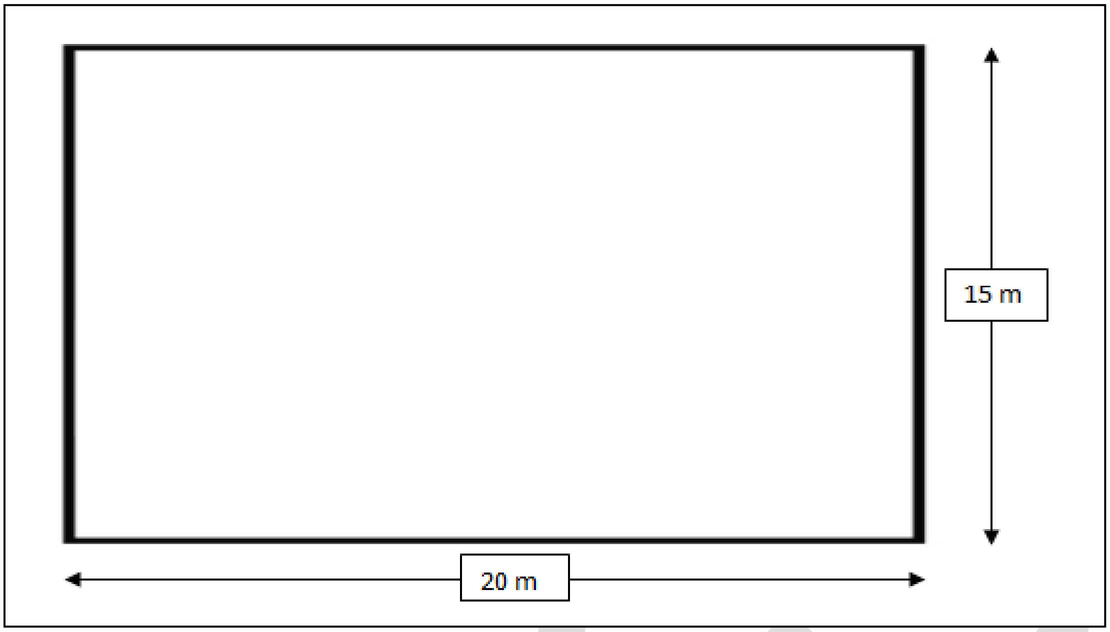


Fig. 1. Plan of Roof Slab

Table – 1
Temperature and rainfall variation of Delhi throughout the year

| Rainfall Data Of Delhi | | | |
|---|---|---|---|
| Month | Mean monthly temperature (max.) (°C) | Mean monthly temperature (min.) (°C) | Mean monthly rainfall (mm.) |
| January | 21 | 7 | 25 |
| February | 24 | 10 | 22 |
| March | 30 | 15 | 17 |
| April | 36 | 21 | 7 |
| May | 41 | 27 | 8 |
| June | 40 | 29 | 65 |
| July | 35 | 27 | 211 |
| August | 34 | 26 | 173 |
| September | 34 | 25 | 150 |
| October | 35 | 19 | 31 |
| November | 29 | 12 | 1 |
| December | 23 | 8 | 5 |
| **Total annual rainfall** | | | **715** |

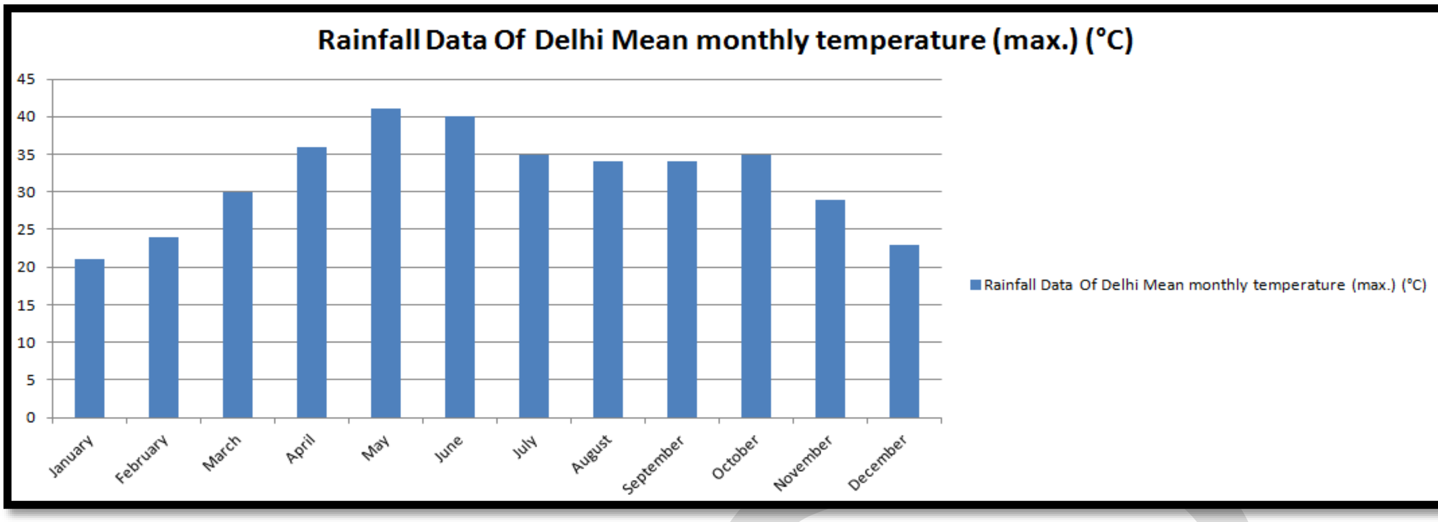


Fig. 2. Temperature (mean maximum) variation in Delhi

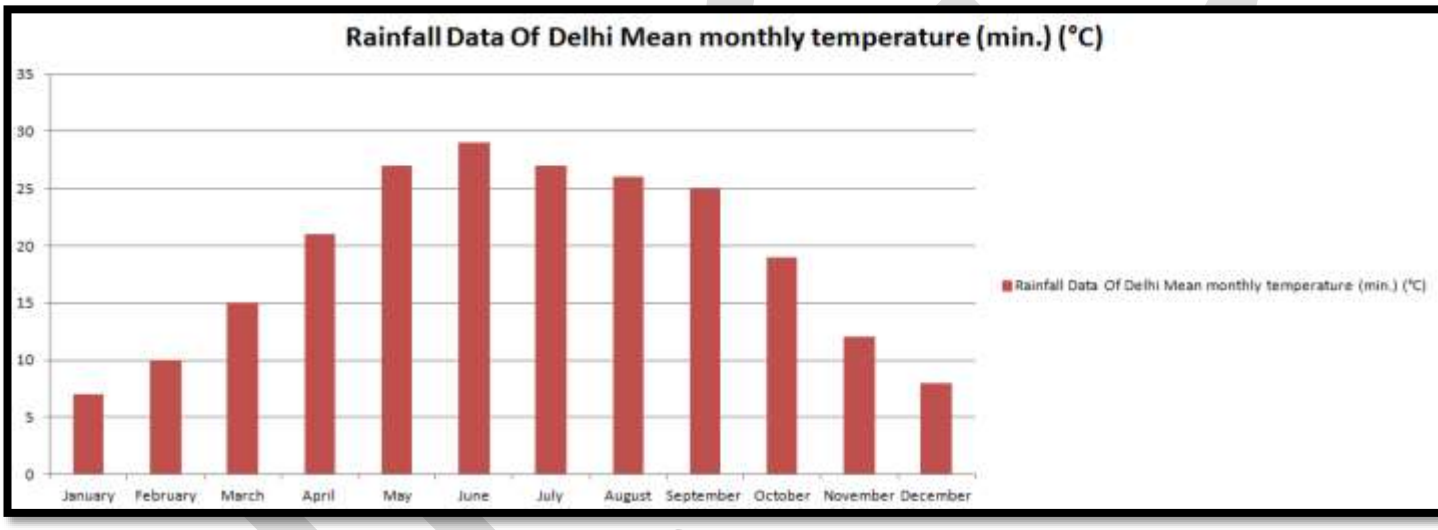


Fig. 3. Temperature (mean minimum) variation in Delhi

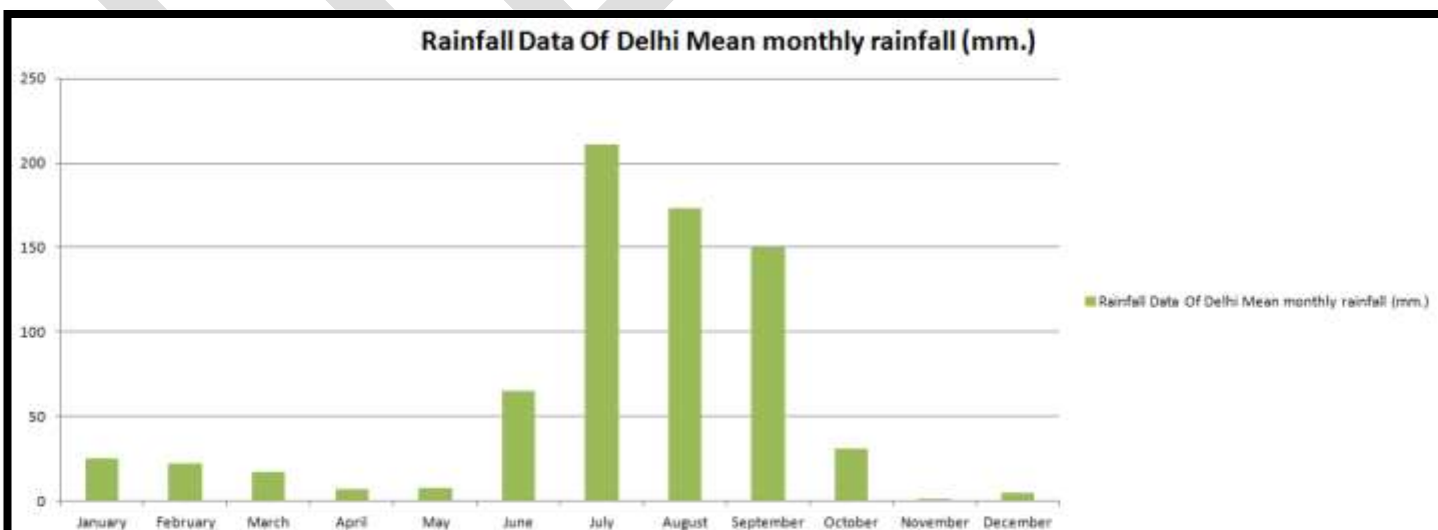


Fig. 4. Mean Monthly Rainfall variation pattern of Delhi

***D. Calculations***

1. As per the catchment area chosen, the calculation of the amount of water which can be harvested in an year is shown below:

   Length of the roof = 20m

   Breadth of the roof = 15m

   Height of rainfall = 0.715m

$$Water\ that\ can\ be\ harvested\ =\ length\ of\ roof\ \times breadth\ of\ roof\ \times height\ of\ rainfall \times water\ density$$
$$= 20m\ \times 15m\ \times 0.715m\ \times 1000 lit/m^3$$
$$= 2{,}14{,}500 litre$$

2. Total area of Delhi = 1,483 $km^2$

   Population projection as in 2021 = 2,20,00,000

   Population density = 14,834 persons/$km^2$ = 0.0148 persons/$m^2$

   Total Population as per the chosen catchment area = $20m \times 15m \times 0.0148 persons/m^2$
   $$= 4.4\ persons$$

   Water demand per capita per day = 135liters

   Water demand for the chosen catchment area per day $= 135 liters \times 4.4 = 594 litres$

   Hence we have taken Average daily use as 600litres

3. Average domestic use of water (demand) per family per year in Delhi (as per observations)

$$Average\ daily\ use\ = 600 litre$$
$$Yearly\ usage\ = \frac{600 litre}{day} \times 365 days\ = 2{,}19{,}000 litres$$

4. Losses:

   We assume an average loss of 20% of total water available from the catchment area that includes evaporation and transmission losses. Calculations are shown below:

$$Losses\ = 20\%\ of\ 2{,}14{,}500 litres$$
$$= 42{,}900 litres$$

5. Final available water

$$Harvested\ water = water\ that\ can\ be\ harvested - losses$$
$$Harvested\ water = 2{,}14{,}500 - 42{,}900 = 1{,}71{,}600 litres$$

On comparison of above data it is found that over 78% of the total domestic demand of water in Delhi can be fulfilled just by rainwater harvesting in accordance with the population projection as in the year 2021. The present population density of Delhi is 0.013 persons/$m^2$. According to present data (2015) the total water demand of Delhi is 1,92,172.50 liters/year for the chosen catchment area. It can also be seen that over 89% of the present water demand of Delhi can be fulfilled by rainwater harvesting.

***E. Project Set-up***

For Delhi, either of the following three techniques can be adapted as per the requirements and availability of resources.

*1. Directly pumping the harvested water to the overhead tank installed at the top of the building in residencial area.*

Block diagram of the complete set-up of direct pumping system is shown in Fig. 5.

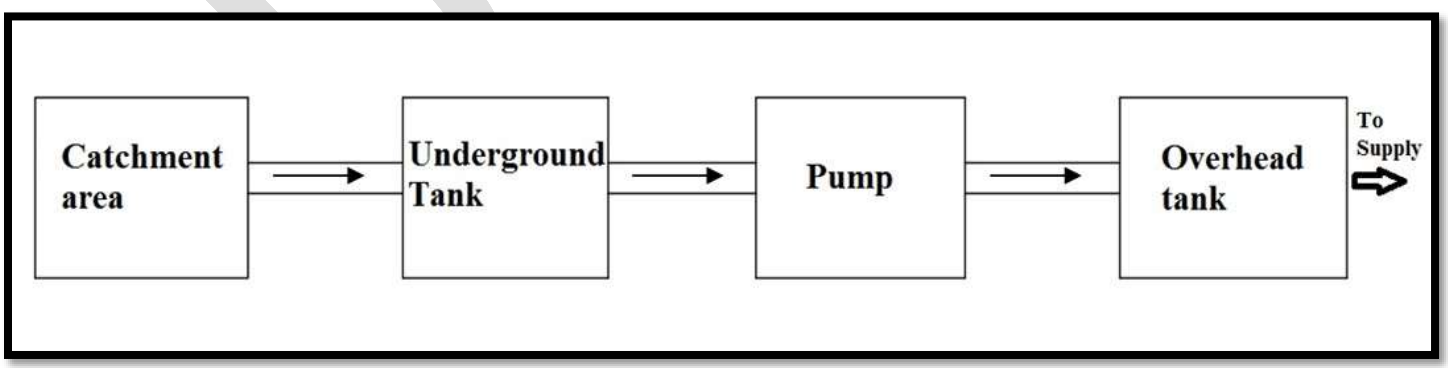


Fig. 5. Block diagram of set-up of RH (pumping method)

Roof serves to be the catchment area where inlet to this area is direct rainfall. Water from catchment area is passed in the underground water tank where the process of filtration takes place. After filtration, water is pumped to the overhead water tank from where it is

supplied for domestic use. A part of water is allowed to percolate into the water table in many cases. A dual mode set-up can be made in the region with heavy rainfall where domestic use as well as percolation both are permitted.
A typical layout of the underground water tank for this method is shown in Fig. 6.

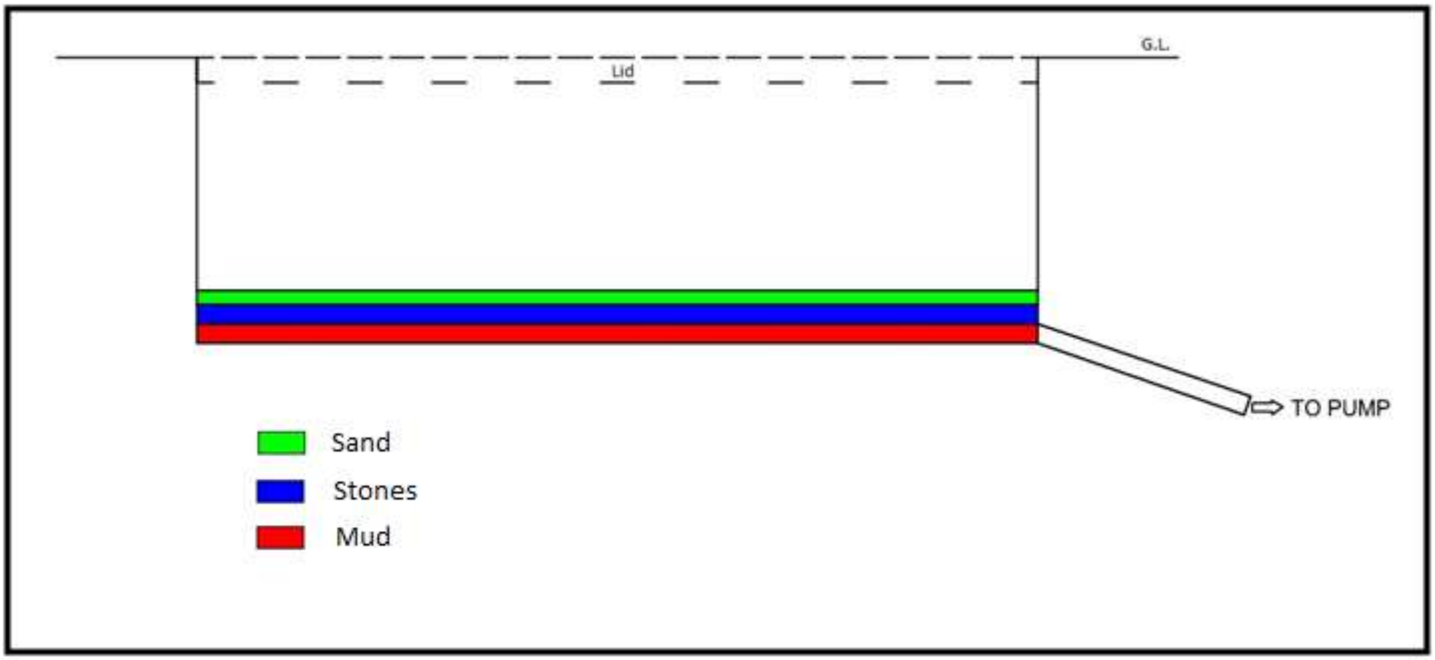


Fig. 6. Typical layout of the underground water tank for RH (pumping method)

If the harvested water contains excess of impurities (synthetic), limestone can be added alongwith stones in the same layer. The layers in the tank are arranged in such a way that it removes the solid wastes from the input water and adds the required minerals to it by natural process as limestone and mud are the best forms of natural water purifiers in themselves.

*2. Boring of the harvested water to the underground water table in open land spaces.*

Block diagram of the complete set-up of direct boring system is shown in Fig. 7.

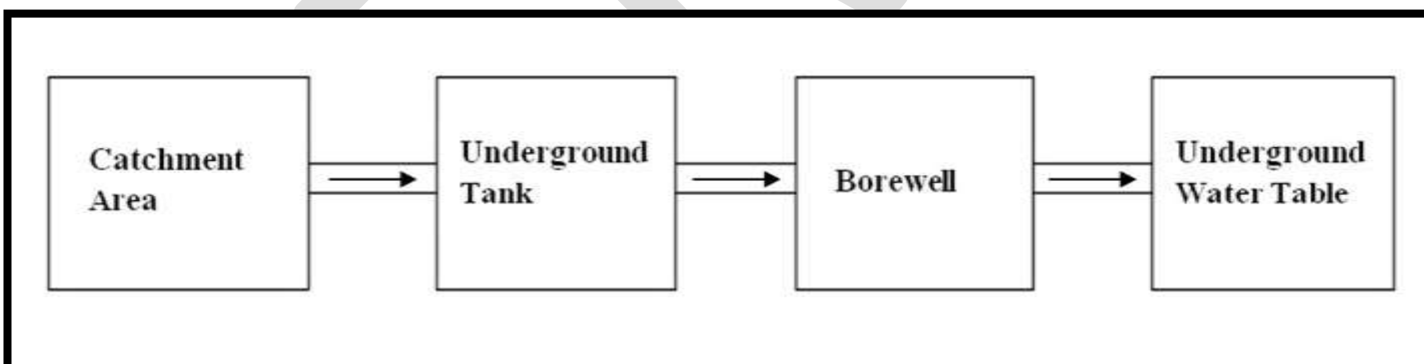


Fig. 7. Block diagram of set-up of RH (boring method)

In this case the harvested water is made to go to the underground water table by installing a bore in the underground tank. This method can be adopted in open land spaces, where instantaneous use of harvested water is not possible. Hence this portion of harvested water serves in increasing the water table.
A typical layout of the underground water tank for this method is shown in Fig. 8.

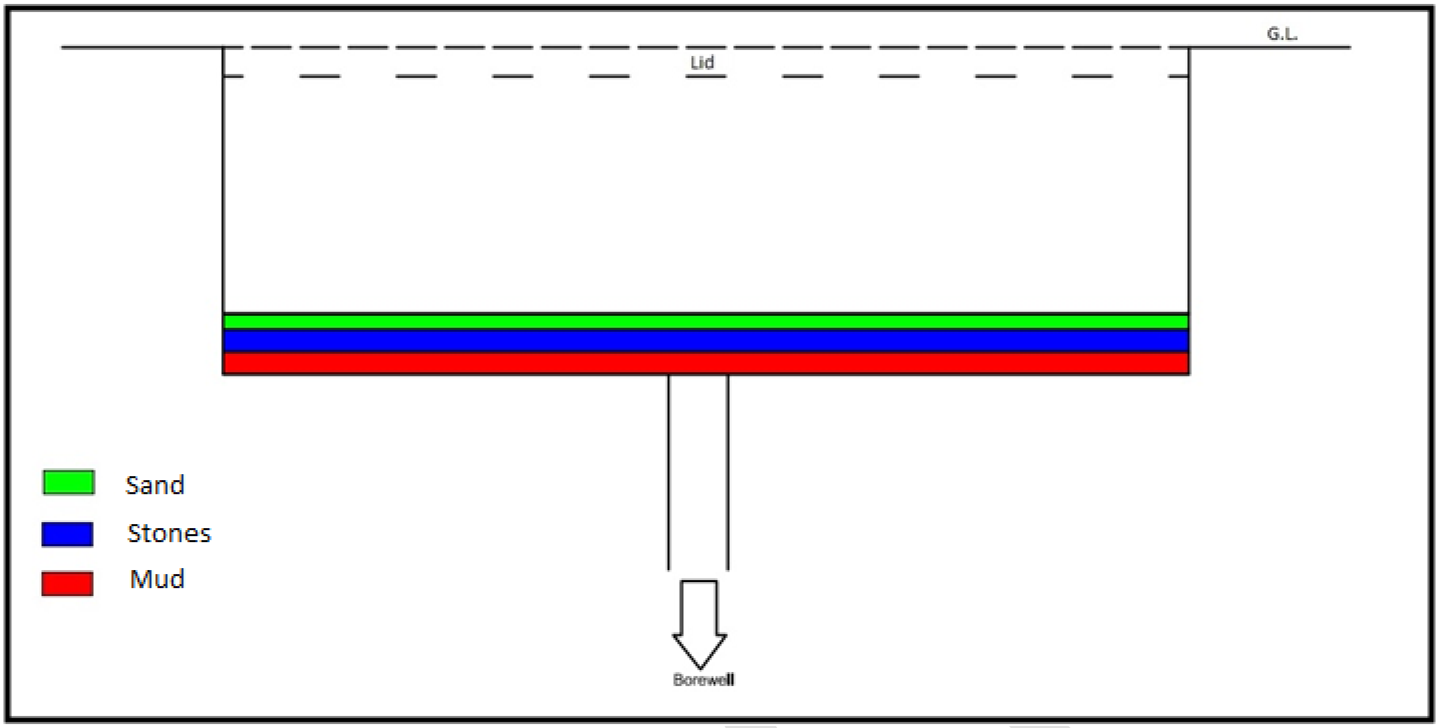


Fig. 8. Typical layout of the underground water tank for RH (boring method)

3. *Combined use of pumping and boring systems.*

Block diagram of the complete set-up of combined pumping and boring systems is shown in Fig. 9.

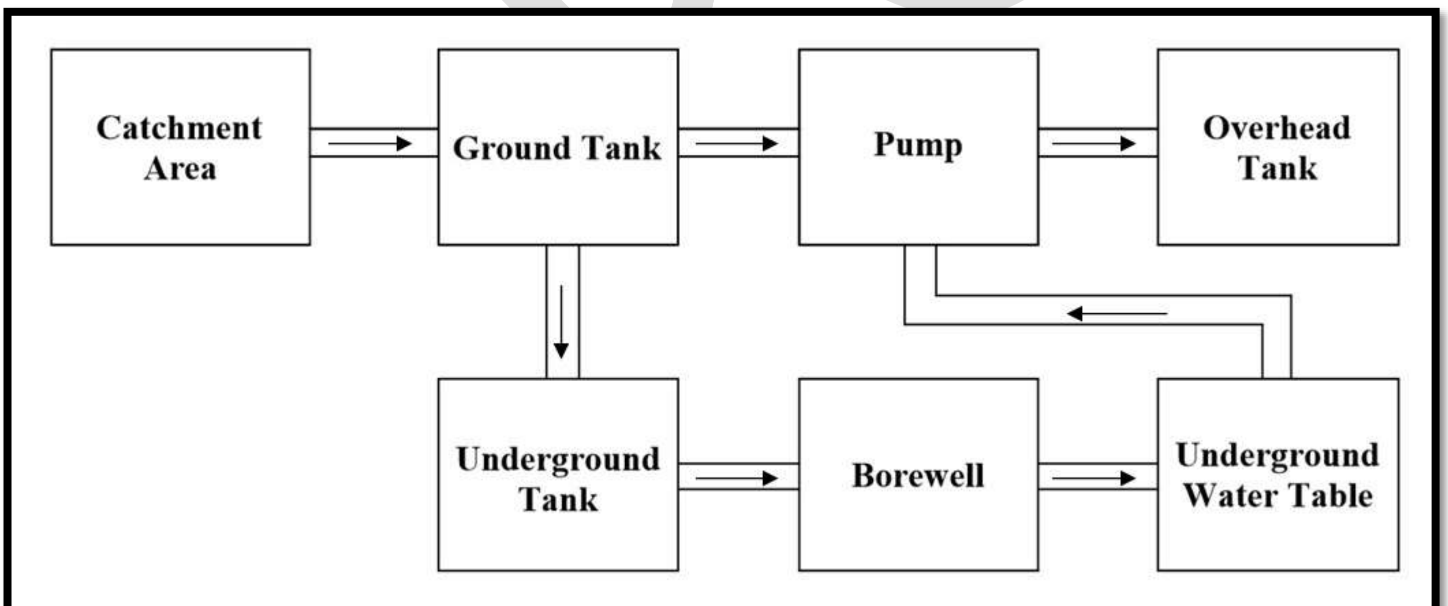


Fig. 9. Block diagram of set-up of RH (combined pumping and boring method)

In this case the water harvested from the catchment area is collected in the ground tank. From the ground tank, it would be pumped to the overhead water tank and can directly be given as supply. It would be designed in such a way that after a certain level, the water would overflow and go to the underground water tank from where it would be passed into the underground water table. This can be used in places where population density is comparitively lower or in a single or two storied building where consumption of water is comparitively less. This in turn increases the level of water in underground water table which can be withdrawn as per necesity or at the time when there is minimum rainfall.

A typical layout of the underground water tank for this method is shown in Fig. 10.

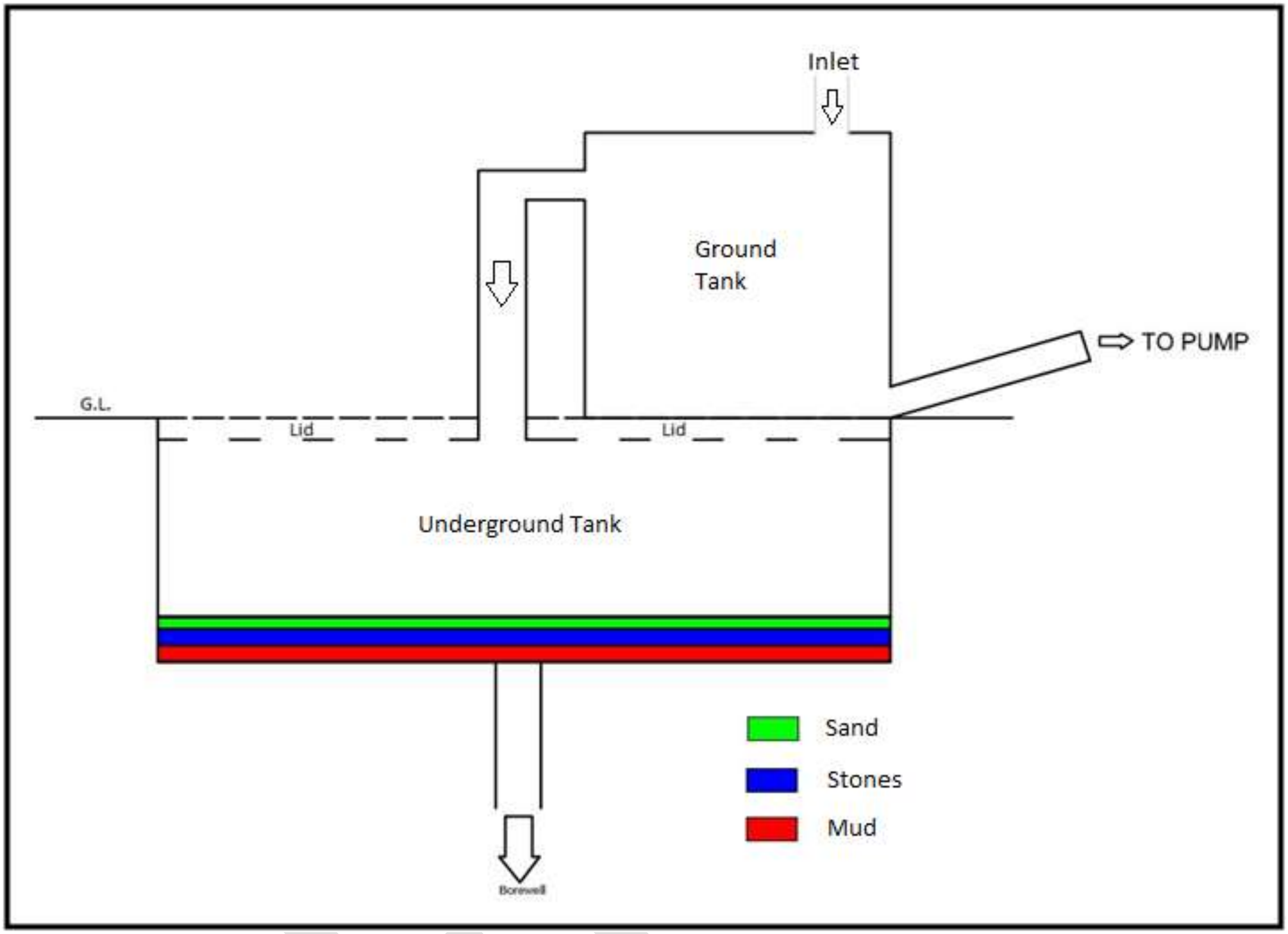


Fig. 10. Typical layout of the underground water tank for RH (combined pumping and boring method)

## CONCLUSION

About 80-90% of the water demand can be fulfilled by harvesting the rainwater. This can be achieved when rainfalls on rooftops, as well as open land spaces, both are harvested. The materials used in the underground water tank are to purify the collected water before use or before boring it into the ground. If the harvested water is found to be synthetic, limestone can be introduced along with stones in the middle layer. Limestone acts as the best natural purifier of water. The walls of the tank made up of stone and lime would be preferred to that made by cement concrete.

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