ENRICHMENT OF GROUND WATER QUALITY USING GEO-MEMBRANE AND GUNNY BAGS BY ROOFTOP RAINWATER HARVESTING IN EDUCATIONAL COMPLEX GOREGAON : A CASE STUDY

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Abstract : The global warming is today' s burning issue all over the world at present India is also facing the same from last few decades. In India drought full conditions arise by reason of global warming affect, unsuitable rainfall distribution as well as local geological and geomorphologic problems. The study area goes through drought like condition during summer season. The heavy rainfall in study area is not effective to recharge aquifer because of unsuitable geology (Hard compact rock layer at shallow depth). Direct aquifer recharge by implementing rainwater harvesting during rainy season possibly the complete solution solves this critical issue. Rainwater harvesting, the process of collection, conveyance and storage having diachronic birthright can be served as better solution for this problem. In the era of urbanization and industrialization, installing high tower building and paving surface is a part of style. But this is resulting in a huge problem of replenishment of ground water. Ground water recharge by rainwater harvesting stands as a best solution for the problem. The main objective of this paper is to design economic model for rainwater harvesting. Current project implemented surroundings of bore well in the premises of government school of Goregaon village of kokan region, dist. Raigad. The geological investigation of study area confirms that existing geology is unsuitable because of very low percolation rate to recharge aquifer and operate as perennial source. It is also observed that the water quality aspects don' t stand to fulfil water standards of World Health Organization. An integrated planning has been done in order to recharge the confined aquifer by rooftop water. This study gives innovative planning and design to enlighten quality and quantity of ground water by using economic material such as gunny bags and geo-membrane. However, the environmental benefits of ground water recharging with less installation cost and better quality water gives new direction to such projects.

IndexTerms - Rooftop water, ground water recharge, gunny bags, Geo-membrane, Rainwater harvesting.

I. INTRODUCTION

Rainwater harvesting is a technique of collection and storage of rain water in surface (storage tanks) or sub surface aquifer before it is lost as surface runoff. There are three basic techniques available for rainwater harvesting among them roof top rainwater harvesting is most suitable and efficient for day today life.

1.1 Need of rainwater harvesting

Water is one of the most essential requirements for existence of living beings. Surface water and ground water are two major sources of water. Due to over population and higher usage levels of water in urban areas, water supply agencies are unable to cope up demand from surface sources like dams, reservoirs, rivers etc. Replenishment of ground water is drastically reduced due to paving of open areas. Indiscriminate exploitation of ground water results in lowering of water table rendering many bore-wells dry. To overcome this situation bore wells are drilled to greater depths. This further lowers the water table and in some areas this leads to higher concentration of hazardous chemicals such as fluorides, nitrates and arsenic. Artificial recharge to ground water is a process by which the ground water reservoir is augmented at a rate exceeding that under natural conditions of replenishment.

To overcome the inadequacy of surface water to meet our demands.
To arrest decline in ground water levels.
To improve ground water quality by dilution.
To enhance availability of ground water at specific place and time and utilize rain water for sustainable development.

1.2 Benefits of rainwater harvesting

Storing water underground is environment friendly.
Promotes adequacy of underground water.
Improves ground water quality / decreases salinity.
The cost of recharging subsurface aquifer is lower.

METHODOLOGY

Basically there are three methods of rain water harvesting. These three methods are listed below,

Storing rain water for direct use.

Recharging ground water aquifers, from roof top run off.

Recharging ground water aquifers with runoff from ground area.

Among these methods second one i.e. recharging ground water aquifers from roof top run off is applied for the study area .In this method rain water that is collected from the roof top of the building and diverted by drain pipes to a filtration tank (bore well, through settlement tank) from which it is delivered to the recharge well. Recharge well should preferably be shallower than the water table. This method of rainwater harvesting is preferable in the areas where the rainfall occurs only for a short period in a year and water table is at a shallow depth.

2.1 Basic assumptions

In order to make an integrated and proper planning, some assumptions have to be done. These assumptions are listed below,

The life of rainwater harvesting system is considered as 50 years.

The life of geo-membrane and gummy bag is considered as 100 years and 10 years respectively.

Runoff coefficient is considered as 0.85.

2.2 Design steps

2.2.1 Surveying

Preliminary Feasibility Survey carried out in Grampanchayat Goregaon premises. Measurements such as Roof area, length of the conveyance system and other existing pipelines were made for design purpose. Site selection was made for the conveyance and storage structures. Levelling method of surveying is used.

2.2.2Catchment area:-

The catchment area is the surface on which the rain water falls. This may be a roof top or open area around the building. The quality of water collected from roof top is comparatively much better than collection from the ground. Rain water harvested from catchment surfaces along the ground should be used for lawn watering, flushing etc., because of increased risk of contamination. This water can also be used for recharging ground aquifers after proper filtration. The rain water yield varies with the size and texture of the catchment area. A smooth, cleaner and more improvised roofing material contributes to better water quality and greater quantity with higher value of runoff coefficient. When roof of the house is used as the catchment for collecting the rain water, the type of roof and the construction material affects the runoff coefficient and quality of collected water. Roofs made of RCC, GI sheets, corrugated sheets; tiles etc. are preferable for roof top collection. But thatched roofs are not preferred as these add colour and purpose should not be collected from roof with damaged AC sheets or from roofs covered with asphalt and lead flashing or lead based paints as the lead dissolved impurities to water. Water to be used for drinking contamination may occur in the collected water.Catchment area for rainwater harvesting is obtained from rooftop of school building, kitchen and toilet.

Table no. I:- Roof Top Area of Site

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

2.2.3 Water testing

Water testing is done in order to check feasibility of the water for drinking purpose .Two water samples from study location were taken for testing, they are: -

Water sample of school bore well.

Water sample of well near to school bore well.

Three types of tests are done. They are as follows,

Hourly test

Daily test

Weekly test

These water samples were tested at Zeal water treatment plant at Mangaon, taluka Mangaon, district Raigad.

2.2.4: Software used

AutoCAD 2008 is used for drawing design and plan of the project site.

MATERIALS

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 fibre, 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.

3.1 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.

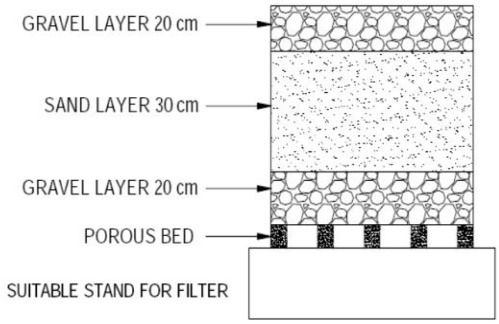

Fig.1: Sand filter

3.2 Charcoal water filter

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

A proportionate layer of Gravel + Charcoal + Sand + Gravel, are used as filter.
The commonly used charcoal water filter is shown in

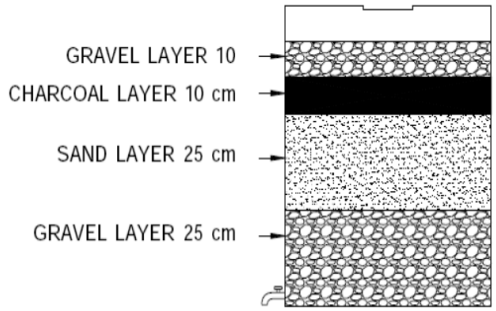

Fig.2 Charcoal water filter

Geo-membrane:-

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 multi -layered bitumen geo-composites. Continuous polymer sheet geomembranes are, by far, the most common.

Gunny Bags-

Gunny bags 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, geo-textile fabrics come in three basic forms: woven (resembling mail bag sacking), needle punched (resembling felt), or heat bonded (resembling ironed felt).

Gunny bags composites have been introduced and products such as geo-grids 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.

Description of Study Area

The water scarcity issues arises in different region of country but as per as our project concern we chose our project site at Goregaon which is a small village having 20 to 25 household. It is located 3km from Mumbai-goa highway in Mangaon taluka, Raigad district is one of the four coastal districts situated along the western coast of the State and is located between north latitude 17°51′00″ and 19°08′00″ and east longitudes 72°50′00″ and 73°40′00″. The climate of the district is typical of west coast and characterized with plentiful and regular seasonal rainfall, oppressive weather in summer and high humidity throughout the year. The mean minimum temperature is 17.7°C and means maximum temperature is 31.8°C. The analysis of long term rainfall data indicates that normal annual rainfall over the district ranges from 2200 mm to more than 3000 mm in the plains and it is above 5000 mm in the hills. The minimum rainfall is in the northwest around Uran (2197 mm) and maximum around Mahad (3360 mm)

The annual rainfall data of Mangaon taluka for the period 2002-2012 is also compiled and is given in Table. The average rainfall for given 5years' ranges from 2253 (Uran) to 7598 mm (Poladpur).

Table II: Rainfall Data

Year	2008	2009	2010	2011	2012	Avg.
Rainfall (in mm)	3183	3987	3666	3358	2194	3481

Goregaon is situated 5km from Dr Babasaheb Ambedakar Technological University and on road of goregaon city. In last month of summer from ending March to June water scarcity is main issue arises. Because of some low population they can be neglected at some time by government institution so for the long time solution we chose that area for rain water harvesting. We chose their infrastructure for rain water harvesting. Total building area of structure is about 96.79$m^{2.}$

Fig- 3: Study area of Goregaon school campus

Ground water quality in that region is good and suitable for drinking and irrigation purposes and type of water is $CaHCO_3$. Major ground water problems and issues**:** In affected areas, ground water quality has also become saline therefore rendering it unsuitable for irrigation. The prominent hill ranges, isolated hillocks, undulation etc., in the district give rise to higher runoff, rather than natural recharge. The formations due to poor storage and transmission characteristics get fully saturated during the monsoon and a situation of rejected recharge is resulted. These aquifers then are drained naturally due to slopping and undulation topography. As a result, the dug well becomes dry by the month of February onwards.

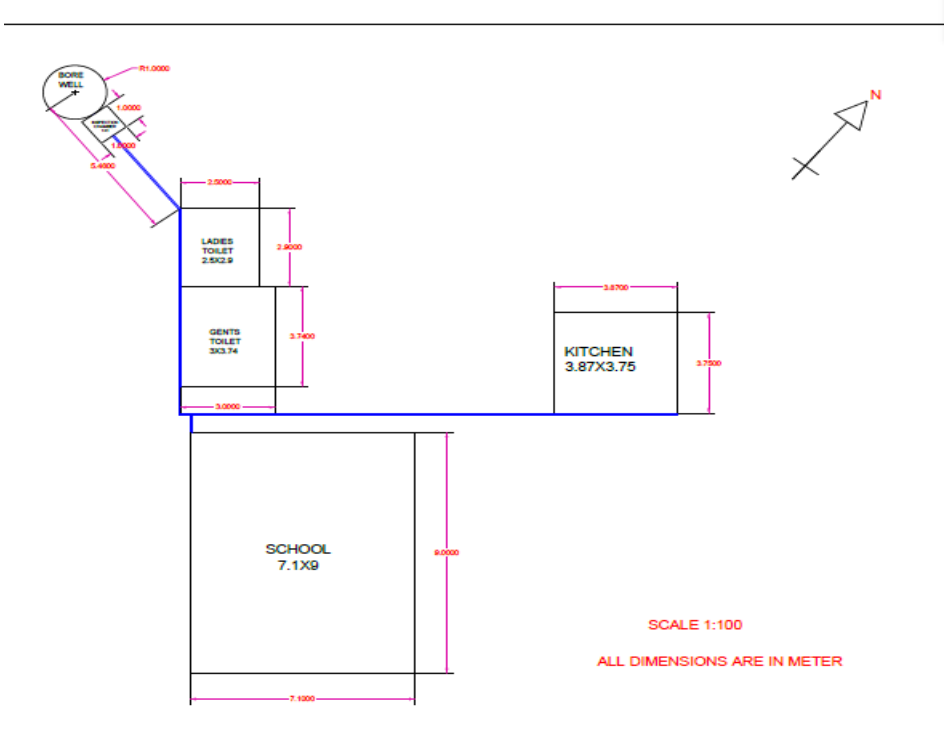

Fig-4: Layout and Working Model of Study Area

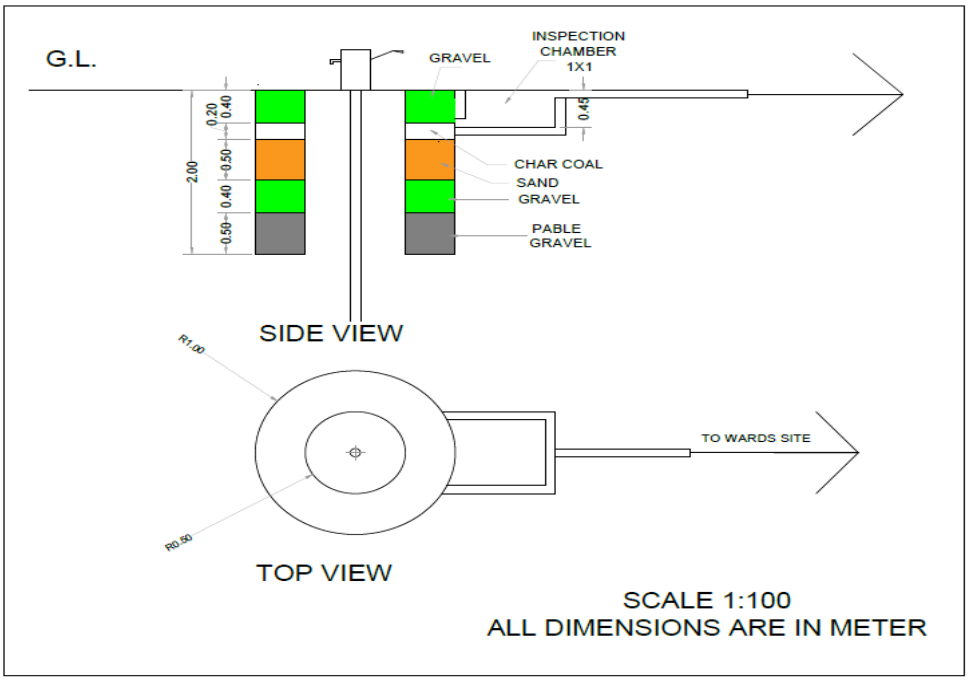

Fig-5: Section of Recharge Pit and Inspection Chamber

Table no. III: Estimated Cost

Sr.no.	Item	quantity	cost
1	Pipe (5 inch dia.)	29.47m	3831 Rs.
2	Gutter (6 inch dia.)	10.51m	1365 Rs.
3	Elbows	9	675 Rs.
4	T – Section	2	300 Rs.
5	Plastic 500µ	63.9 m^2	6134.4 Rs
6	Cement	17 bags	2730 Rs.
7	Sand	1.24m^3	1860 Rs.
8	Brick	2308	11540 Rs.
9	Excavation	8.575m^3	1230 Rs.
10	Mason	2	868 Rs.
11	Mazdoor	8	2776 Rs.
12	Bhisti	2	654 Rs.
			Total = 33,963 Rs.

CONCLUSIONS

Recharging the ground water is gradual process.Low cost adoptable technology i.e. purifying the rain water from roof top surface. We hopefully say that water quality should be improved. The region is affected by water scarcity and drought effect in summer season. This improves quality of water and makes it feasible for drinking purpose. Thus, it is concluded that recharging of ground water it is the best technique for this region.

FUTURE SCOPE

Total area harvested is only 17% of premises area.
Remaining 83% area is unpaved and semi paved can be included in harvested area.
This system can be adopted by each and every one in the locality since it is economical.

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