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Groundwater recharge through rooftop rainwater harvesting

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■ **ABSTRACT :** Artificial ground water recharge is an effective way to counter the adverse effects of declining water table of Punjab. Most of the rainfall was received during the months of July, August and September in Hoshiarpur district during 2011-2013. The average rainfall received for year 2011-2013 is 768.6 mm. The maximum rainfall of 236.6 mm (28.7%) was received in the month of August and the minimum rainfall of 3.1 mm (0.4%) was received in the month of November. Excessive rainfall in the district causes excessive runoff and sediment loss due to undulating terrains. Rooftop rainwater harvesting during rainy season holds good potential for recharging the depleting groundwater aquifiers. A rooftop rainwater harvesting structure having siltation unit (1.5 m x 0.75m x 1.5m), filtration unit (1.5x 0.30m x 0.9m) and storage tank(1.5 m x0.45m x 0.9 m) was constructed and evaluated at Krishi Vigyan Kendra, Hoshiarpur. This structure contributed an average of 2.04 lakh litres groundwater recharge. The study revealed that there was a need to adopt this technique at mass level to get significant results. This would be possible only with the help of people participation.

■ **KEY WORDS :** Ground water, Rooftop, Rainwater harvesting, Groundwater recharge

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Punjab is experiencing the problem of declining water table due to over pumping of groundwater. The water table is declining at the rate of 0.9 m/year. Out of 142 blocks in the state, 107 blocks have already declared "dark blocks" where the draft rate is more than the recharge. White blocks fall only in the south-western Punjab where underground water is not of good quality (Gill, 2012). The number of tube wells increased from 0.192, 0.60, 0.80 and 1.073 million in 1970-71, 1980-81, 1990-91 and 2000-01, respectively to 1.232 million presently. The average rainfall in the state was 672.3, 739.1, 754.6 an 391.9 mm in 1970, 1980, 1990 and 2000, respectively (Anonymous, 2007). The current level of groundwater withdrawal has passed the sustainable limits. It is affecting the performance of shallow tubewells and farmers have been forced to use deep well submersible pumps in place of centrifugal pumps resulting in huge additional expenditure and extra power consumption. The artificial ground water recharge is an effective way to counter the adverse effects of declining water table. The main source of water for artificial groundwater recharge is rainwater. This may be tapped either directly from the rooftop or from surface runoff. However, in the latter case, the quality of water is major concern, since this may contain pathogenic bacteria besides other physical and chemical contaminants. So it becomes necessary to treat this water before using it for recharging. But roof rain water can be recharged after filtration and it does not contain any harmful contaminants but may some surface contamination due to silt, clay etc. Roof top rainwater harvesting during rainy season holds good potentials in Punjab. In Punjab, there are 13,76,189 and 25,45,919 residntial houses in urban and rural areas, through which 197.7 M m^3 of rainwater can be harvested every year. On an average with 1 cm of rainfall one can harvest 1000 litres of water from 100m^2 roof area. In central Punjab, on an average one can harvest 50,000 litres of rainwater from 100m^2 roof area (Aggarwal *et al*., 2011). Rooftop rain water harvesting not only improves the quality of ground water through dilution but also checks the declining of water table problem to some extent. It also reduces soil erosion and helps in reducing the mosquito's problem as it reduces the chances of stagnation of water on road side.

Thomas (2000) discussed the advantages of use of rainwater harvesting and Gould (2000) carried out case studies on rainwater harvesting in different countries and examined the possibility of rainwater harvesting. Various

issues like rainwater quality, household rainwater harvesting etc were discussed by Ariyabandu *et al*. (2000). The feasibility of rainfall roof catchment systems as a supplementary source was investigated by Sharesk (2002) for domestic water supply in the west bank, Palestine and found that rainwater harvesting can be used as supplementary source of water supply.

METHODOLOGY

Roof top rain water harvesting structure was constructed at Krishi Vigyan Kendra, Hoshiarpur by Department of Soil Water and Engineering, Punjab Agricultural University, Ludhiana in 2010.

Components of rainwater harvesting structure:

Collecting pipes:

There are 100mm diameter PVC pipes which collect rainwater from rooftop and guide it to the rainwater harvesting structure towards siltation tank. The collection pipe should be well connected.

Filtration unit:

It is a brick lined pit divided into three units. First unit acts as siltation tank (part of silt collected from rooftop gets settled in this unit), second as filtration unit fitted with pea gravels and third as outlet chamber which is connected to recharge well s shown in Fig. A.

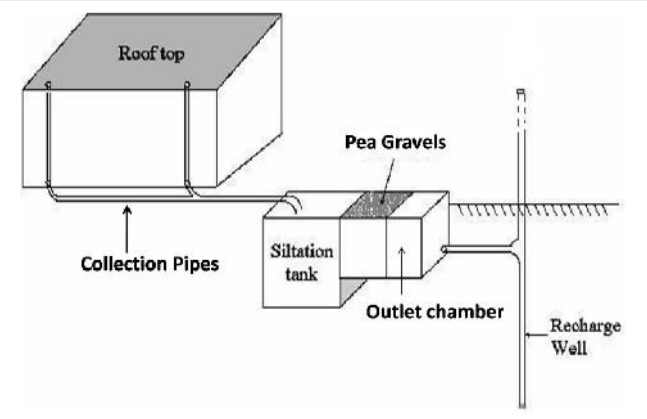

Fig. A : Schematic diagram for rainwater harvesting through rooftop

Recharge well:

It is a 100 mm diameter borewell with PVC pipe lowered into dry sand with strainer. It should have vent on the top portion.

The method consists of collecting rainwater from the roof top of building having area 266m^2 and diverting it via PVC collector pipes to a silt trap cum filtration unit. The top level of this unit is kept slightly above the ground surface so as to avoid entry of surface water of the nearby area. Water from the rooftop gets collected in the siltation tank of the size 1.5 m x0.75m x 1.5m where a part of the silt gets settled. This water then passes through filtration unit (1.5m x 0.30m x 0.9 m) of 30 cm thick layer of pea size gravels. This is packed between two frames made of iron mesh that in turn covered by nylon mesh. The suspended silt particles in the water are trapped in the filtration unit. After filtering the rainwater, it is conveyed to a storage tank of 1.5 x 0.45 x 0.9 m size connected to the recharge well. The entire unit is covered with iron gate so as to avoid the entry of surface water. Fig. B shows the rooftop rainwater harvesting structure constructed at KVK, Hoshiarpur.

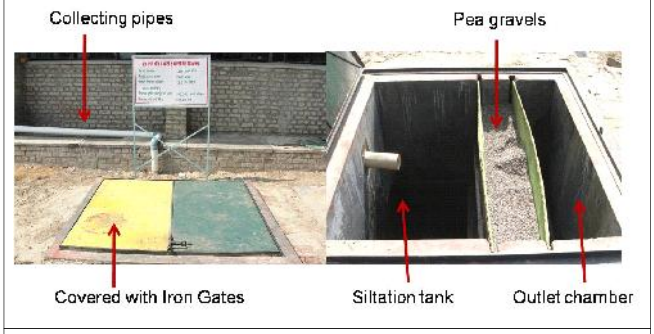

Fig. B : Rooftop rainwater harvesting structure

The rainfall data were collected from Automate weather station (AWS) installed by Indian Metrological Department at this KVK as shown in Fig. C. It periodically measures various meteorological parameters and stores for future reference. All the meteorological data are stored in the Data logger and transmit the data into pen drive. The data in the pen drive are transferred into the computer by using AWS Software. Fig. D shows the data logger in AWS.

Fig. C : Automatic weather station

Fig. D : Data logger of automatic weather station

In order to measure rainfall, the tipping bucket rain gauge is used as shown in Fig. E. The body and funnel are made of FRP (Fibre glass reinforced plastic), rim is made of gun metal. All parts having contact with water are made of stainless steel. Rainfall entering through funnel collector is directed to the tipping bucket assembly. When an incremental amount of rainfall has been collected, the bucket tips ad activates a signal. The specifications of rainfall sensor are given in Table A.

Fig. E : Tipping bucket rainfall sensor

Table A : Specifications of rain gauge sensor

Sensor	Tipping bucket rain gauge
Sensing	Magnet and reed switch
Resolution	0.5mm
Accuracy	1mm
Operating temperature	0°C to 60° C
Rim diameter	203mm
Collecting area	325 mm
Sensitivity	0.5mm (rainfall per pulse)

RESULTS AND DISCUSSION

Hoshiarpur district present in north east of Punjab lie between the latitude of 31°07'58'' and 32°05'13''. It covers an area of 3392 sq. km. The climate of Hoshiarpur is semi arid hot. The south western monsoons bring much needed rain during summer (July to September). Table 1 shows the rainfall data for the year 2011-2013. Fig. 1 shows the percentage wise of rainfall received during the year 2011-2013. Most of the rainfall was received during the months of July, August and September. Excessive rainfall in the district causes excessive runoff and sediment loss due to undulating terrains but it also provides the scope for harvesting extensively the rain water. The average rainfall received for year 2011-2013 was 768.6 mm. The maximum rainfall of 236.6 mm (28.7%) was received in the month of August and the minimum rainfall of 3.1 mm (0.4%) was received in the month of November.

Table 1 : Rainfall (mm) data for the year 2011-2013

No. of the month	Rainfall (mm)			
	2011	2012	2013	Average (2011 to 2013)
January	15.7	10.7	29.3	18.6
February	30.2	25.8	45.5	33.8
March	35.3	47.5	12.7	31.8
April	25.1	12.7	45.6	27.8
May	16.8	10.7	29.8	19.1
June	75.7	73.4	98.5	82.5
July	193.2	203.9	216.5	204.5
August	245.2	278.6	185.9	236.6
September	149.1	154.0		151.6
October	0.0	16.7		8.4
November	6.2	0.0		3.1
December	9.6	5.9		7.8
Total	802.1	839.9	663.8	825.5

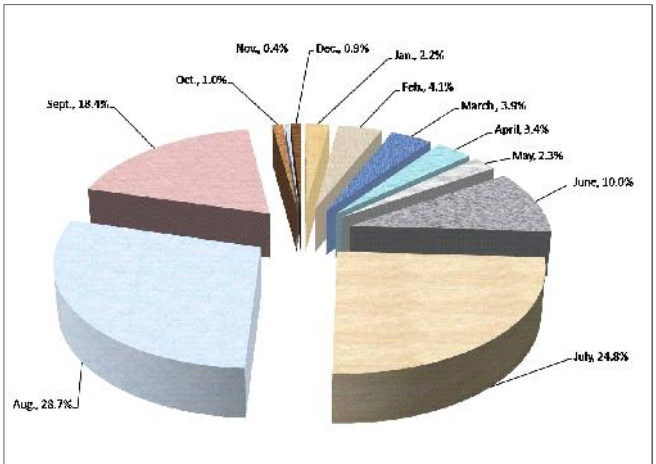

Fig. 1 : Percentage of rainfall received during the year 2011-2013

Table 2 shows the total recharge (litres) from rooftop rainwater harvesting structure during the year 2011-2013. Fig. 2 shows the percentage of total recharge from rooftop rainwater harvesting structure during the year 2011-2013. The average recharge from rooftop rain water harvesting structure for year 2011-2013 was 2,04,447.6 . The maximum recharge of rainwater of 62926.7 litres (30.7%) was received in the month of August and the minimum recharge of rainwater of 549.7 litres (0.3%) was received in the month of November.

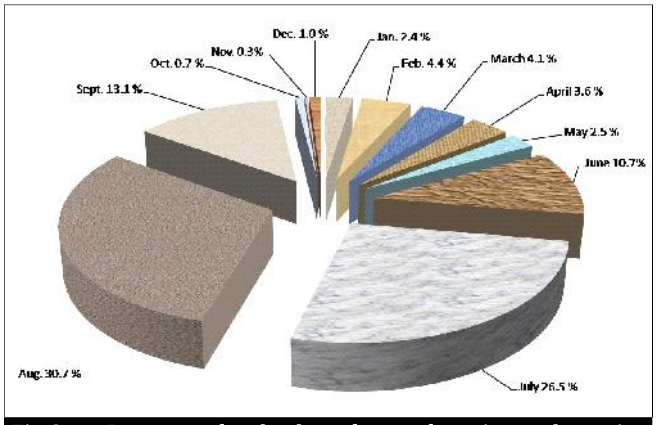

Fig. 2 : Percentage of total recharge from rooftop rainwater harvesting structure during the year 2011-2013

improved by cleaning the filtration unit periodically or by not allowing the first rain storm water through filtration unit. The roof should be cleaned before the onset of rainy season. Filtration unit and siltation tank should be cleaned at least once before the rainy season. Filtration unit and siltation tank should be monitored regularly. Different training programmes on rain water harvesting (Fig. 3) were organized at this KVK so that this technology can be adopted at mass level.

Fig. 3 : Training programme on rooftop rain water harvesting at KVK, Hoshiarpur

Table 2 : Total recharge (litres) from rooftop rainwater harvesting structure

Name of the month	Total recharge (litres)			
	2011	2012	2013	Average (2011 to 2013)
January	4176.2	2846.2	7793.8	4938.7
February	8033.2	6862.8	12103.0	8999.7
March	9389.8	12635.0	3378.2	8467.7
April	6676.6	3378.2	12129.6	7394.8
May	4468.8	2846.2	7926.8	5080.6
June	20136.2	19524.4	26201.0	21953.9
July	51391.2	54237.4	57589.0	54405.9
August	65223.2	74107.6	49449.4	62926.7
September	39660.6	40964.0	-	26874.9
October	0.0	4442.2	-	1480.7
November	1649.2	0.0	-	549.7
December	2553.6	1569.4	-	2061.5
Total	213358.6	223413.4	176570.8	205134.8

Cost of the structure is site specific it depends upon the roof area, rainfall pattern and geological condition of the area. But in general the cost varies from Rs.25,000 to 50,000 for 100 to 500 m^2 roof area. The life of these structures is 15-20 years. The life and efficiency can be

Conclusion:

The rainwater harvesting through rooftop for groundwater recharge will not only improve the quality of ground water but also check the declining water table problem, improve the roads condition, reduce load on sewage

system and reduce health problems. There is need to adopt this technique at mass scale to get significant results. This will be possible only with the help of people's participation. To improve the performance of this structure and increase the life of recharge well, attempt should be made to drain out first shower of rain and clean the filter before the onset of monsoon.

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