International Journal of Agricultural Engineering, Vol. 4 No. 1 (April, 2011) : 113 -119

A Case Study :

Design of roof top rainwater harvesting system at CAET, Akola

V.G. NIMKALE, **H. SANCHAVAT AND** S.B. JAJOO

Received : January, 2011; Accepted : February, 2011

See end of the article for authors' affiliations

Correspondence to:

H. SANCHAVAT
Department of Renewable Engineering and Technology, College of Technology and Agricultural Engineering, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA
Email : hiteshsanchavat@rediffmail.com

ABSTRACT

Groundwater is the great hidden component of the hydrological cycle. The depleting resource of ground water is matter of great concern to human society. Though ground water is renewable resource but it has also reached to critical stage, therefore, its appropriate management has assumed great significance. Hence, along with natural recharge, all possible means of artificial recharge should be used with different technologies and methods available. The rainwater harvesting technique is important which was adopted in this study. Building of College of engineering and technology, Akola was selected for design of roof top harvesting system. In this study, the total rainfall collection in recharge pit, cost of construction of system per m^2 of slab area, recharge cost per m^3 of water and the total area of CAET building and the estimated volume of water recharge under study were calculated. If we design recharge pit considering 40 mm rainfall depth, 82.58 % of total rainfall will be collected in recharge pit. Cost of construction per m^2 of slab was Rs. 2.78/- and recharge cost of m^3 of water was Rs. 0.88/-. The total area of CAET building was 5403 m^2 and estimated annual volume of water recharge from this area was 3414.76 m^3.

Nimkale, V.G., Sanchavat, H. and Jajoo, S.B. (2011). Design of roof top rainwater harvesting system at CAET, Akola. *Internat. J. Agric. Engg.*, **4**(1) : 113-119.

Key words : Rain fall intensity, Water harvesting

In most of the area the water supply sector is facing number of problems and constraints. The rapid pace of growth of population and consequent urbanization has led to stress on available water resources due to over use of surface supplies and over exploitation of ground water. Dependence on ground water, to meet various requirements is so heavy that water levels are declining rapidly so dug wells and bore wells are even drying up. Failure of monsoon makes the situation worse (Murthy *et al.,* 2000). As surface water sources fail to meet ever increasing demands, ground water resources are tapped, often unsuitable levels. The rapid urbanization has also introduced reduction in original permeable ground surface for natural recharge of rainwater (Rao *et al.*, 2000).

The imbalance between excess withdrawal of ground water and the insufficient replenishment of ground water adversely affected the water table. This is controlled to some extent by adopting used of every drop of water judiciously, efficiently and water recharge techniques. Along with the natural recharge, all the possible means of artificial recharge should be used with different technologies and methods available (Mehta *et al.,* 2008) The roof top rain water harvesting system is one of them and adopted here. In order to harvest, the roof of the building college of Agricultural Engineering and Technology, Akola was considered. The Average annual rainfall of Akola is 790 mm. For study the daily rainfall data of 33 years of Akola were analysed, interpreted for design of RWH system at college (Taneja *et al.*, 2003).

Rainfall analysis:

Daily rainfall data for the period from 1971 to 2003 were collected from Meteorological department, Dr. PDKV, Akola. The annual rainfall of the area is 790 mm, which is received nearly in 36 days concentrated over the months June to October. To design the roof top rainwater harvesting system, daily rainfall were analyzed on following lines. Distribution of daily rainfall amount. Average rainfall depth in different intensities during June to October. Then decide the depth of rainfall to be considering for the design of recharge pit.

Distribution of daily rainfall:

The daily rainfall of 33 years period (1971–2003) during different months of rainy season were analysed and classified the distribution of daily rainfall amount. The Table 1 indicates distribution of daily rainfall amount of Akola during *Kharif* season. Daily rainfall amount is

Table 1 : Distribution of daily rainfall amount of Akola during *Kharif* season (1971-2003)

Months	Daily Rainfall, mm						Total
	Upto10	10-20	20-30	30-40	40-50	>50	
June	19.84	31.50	14.68	12.11	25.92	48.65	152.70
	(13.00 %)	(20.62%)	(9.61%)	(7.93%)	(16.97%)	(31.87%)	(100%)
July	31.68	35.62	24.43	25.64	20.00	58.62	195.99
	(16.16%)	(18.18 %)	(12.47 %)	(13.08 %)	(10.20%)	(29.91%)	(100 %)
Aug.	29.31	36.02	24.81	25.68	13.40	79.69	208.91
	(14.03 %)	(17.24 %)	(11.87 %)	(12.29 %)	(6.42 %)	(38.15 %)	(100 %)
Sept.	19.12	14.47	21.42	10.50	11.72	32.52	109.75
	(17.42 %)	(13.19 %)	(19.52 %)	(9.56 %)	(10.68 %)	(29.63 %)	(100 %)
Oct.	9.85	8.98	7.65	5.93	2.96	17.39	52.76
	(18.67 %)	(17.02 %)	(14.50%)	(11.23 %)	(5.62 %)	(32.96 %)	(100 %)
Seasonal	109.80	126.59	92.99	79.86	74.00	236.87	720.11
Total	(15.25 %)	(17.58 %)	(12.91 %)	(11.09 %)	(10.28 %)	(32.90%)	(100 %)
Cumulative	(15.25%)	(32.83 %)	(45.74 %)	(56.83 %)	(67.11 %)	(100%)	--

classified in six categories *i.e.* up to 10 mm, 10 to 20 mm, 20 to 30 mm, 30 to 40 mm, 40 to 50 mm and above 50 mm. Maximum rainfall occurs above 50 mm (32.9%) fallowed by 10 to 20 mm (17.58 %) and the minimum rainfall occurs in between 40 to 50 (10.28%). The daily rainfall during *Kharif* season below 40 mm is 56.83% and above 40 mm is 43.17%. The rainfall above 50 mm is in the range jof 29.67% to 38.15% during different months of *Kharif* season.

Depth of rainfall in different intensity classes:

The rainfalls of 14 years period (1988-2001) during

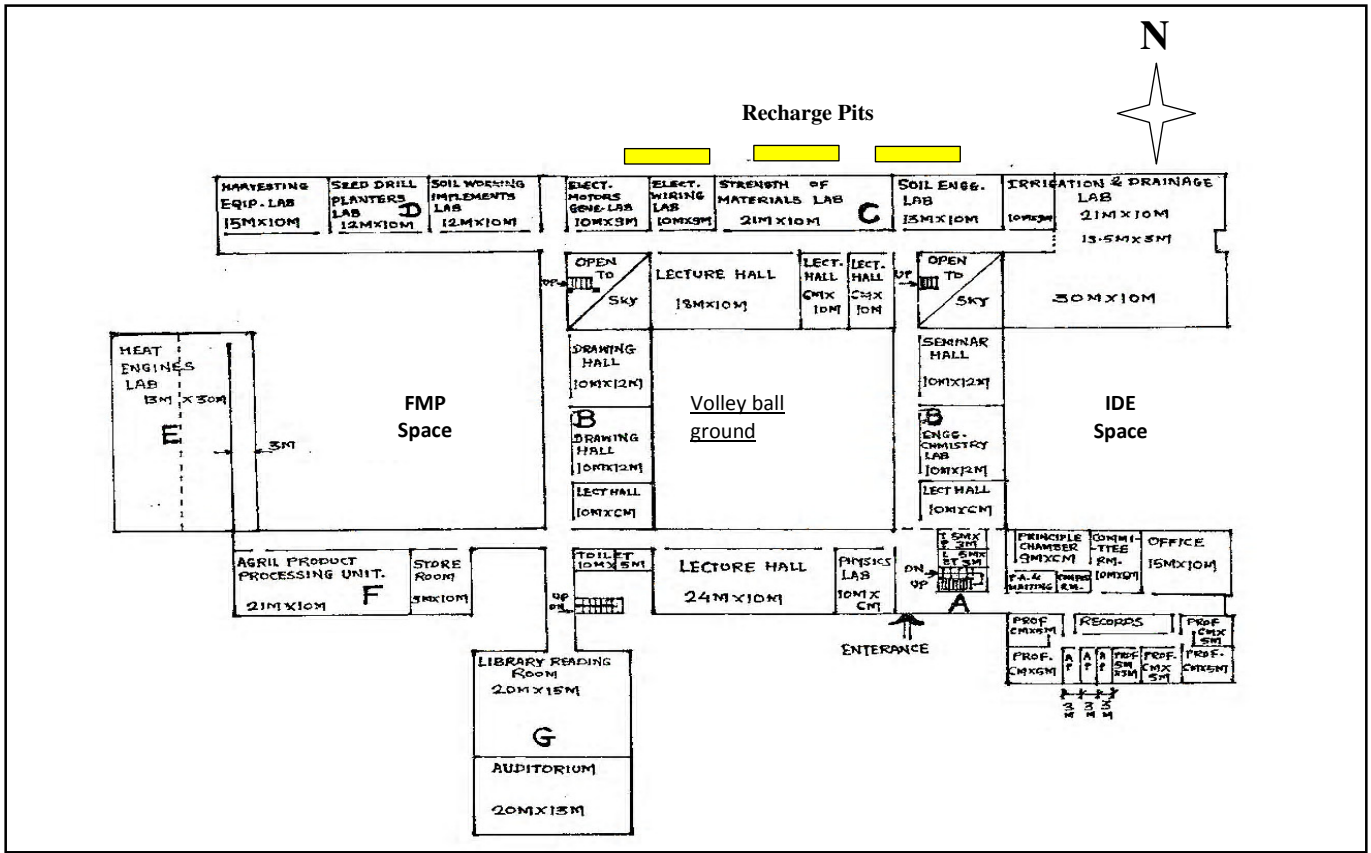

Fig. 1 : Map of CAET Building

different months of the rainy season were analyzed to classify the distribution of amount of rainfall on intensity basis. The Table 2 reveals that, on an average maximum depth of rainfall (19.83 cm) occurs in the month of August followed by July (16.83 cm) and June (14.72 cm). The total depth of rainfall (66.90 cm) of monsoon, on an average 44.52 per cent rainfall is below 1.0 cm/hr class and 9.82 per cent in highest intensity class (above 5 cm/hr). 62.15 per cent rainfall occurs below 2 cm/hr intensity, which can be conserved and does not contribute to runoff but the remaining 37.85 per cent rainfall depth which is received with intensity greater than 2 cm/hr, amount that 28.03 per cent moderately heavy rainfall intensity is between 2 to 5 cm/hr and remaining 9.82 per cent rainfall having high intensity, which may be contribute to runoff.

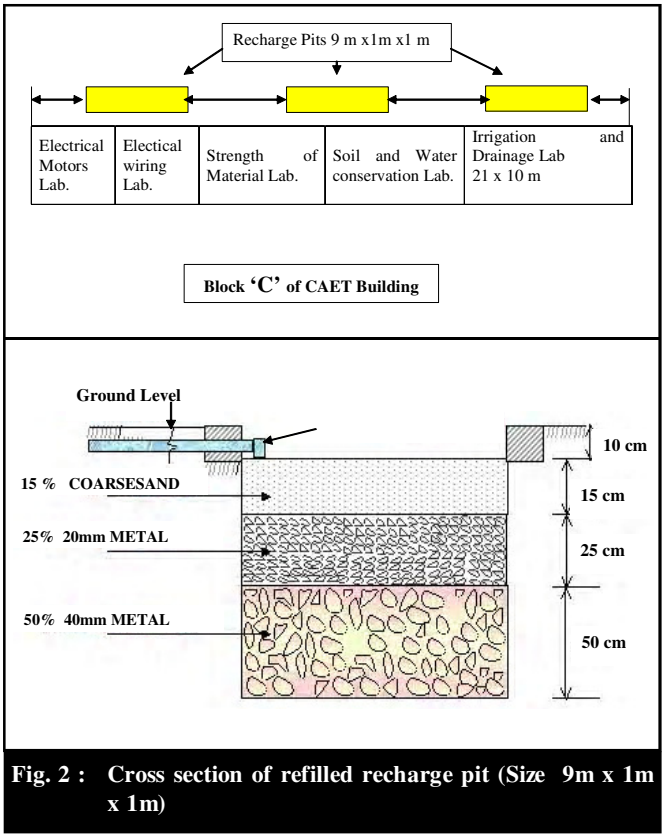

Fig. 2 : Cross section of refilled recharge pit (Size 9m x 1m x 1m)

Rainy days

The numbers of rainy days at Akola in different months of rainy season during the year 1971-2003 are presented in Table 3.

Table 3 reveals that the maximum average rainy days were found in the month of August (10.12) fallowed by July (10.10) and the minimum rainy days occured in the month October (2.81). The maximum rainy days were recorded in the year 1994 (50) fallowed by 1988 (49) and the minimum rainy days in 1991 (24). The average rainy days during the year 1971-2003 were 36.18.

Design and constraction of roof top rain water harvesting system at College of Agriculture Engineering and Technology (CAET), Akola:

The building of CAET, Akola was divided in seven blocks (*i.e.* A, B, C, D, E, F, and G). The details of design and construction of roof top rainwater harvesting system of CAET Akola is discussed below.

Half side of 'C' block (North side):

The half side of 'C' block (North side) have 82 m length in which 53.5 m length having width 10.0 m and for remaining length (28.5m) width is 11.5 m thus total area of this side is 862.75 m^2. The height of the slab is 3.75 m. Along the length at 3m apart 27 drain pipes of 10 cm diameter are provided to drain out the rain water. Behind the CAET'S building there is a CAET'S farm.

There is no open/ bore-well or constructed water tank were we could collect the water or pour the water. Therefore it has been planned to recharge the water by constructing recharge pit. A soil stratum below 1m depth is of hard murum so depth of recharge pit decided as 1m.

Considering 40 mm of daily rainfall depth and 0.80 runoff coefficient of cement concrete maximum volume

Table 2: Average monthly rainfall depth (cm) indifferent intensity classes (cm/hr) during yar (1988-2001) at Akola

Month	Intensity classes (cm/hr)						Total rainfall
	Below 01	1 -2	2 –3	3 - 4	4 - 5	Above 5	cm
June	5.86	1.67	2.25	1.44	1.62	1.88	14.72
July	9.20	3.11	1.29	0.93	0.88	1.42	16.83
August	10.31	4.17	1.75	0.82	0.97	1.51	19.83
September	2.80	1.82	1.40	1.37	1.09	1.19	9.67
October	1.62	1.03	0.88	0.78	1.27	0.57	6.15
Total	29.79	11.80	7.57	5.34	5.83	6.57	66.90
% of total	44.52	17.63	11.32	7.99	8.72	9.82	100
Cumulative %	44.52	62.15	73.47	81.45	90.18	100	-

Table 3 : Numbers of rainy days at Akola in different months of rainy season during year (1971 – 2003)

Year	June	July	August	September	October	Total
71	7	5	7	8	3	30
72	9	7	11	4	0	31
73	7	14	13	6	3	43
74	4	10	8	5	7	34
75	6	11	11	10	6	44
76	3	14	11	6	0	34
77	13	12	10	6	2	43
78	10	15	9	3	2	39
79	7	10	12	5	0	34
80	12	9	13	4	0	38
81	8	15	9	13	1	46
82	2	12	8	4	1	27
83	7	12	16	11	3	49
84	7	5	9	3	4	28
85	7	10	7	2	3	29
86	9	7	9	4	0	29
87	9	9	10	1	4	33
88	6	13	11	16	3	49
89	7	9	12	7	0	35
90	9	8	11	1	6	35
91	8	12	4	0	0	24
92	8	5	16	5	4	38
93	8	11	11	7	3	40
94	8	17	17	6	2	50
95	8	13	3	5	0	29
96	1	10	9	7	10	37
97	4	12	10	3	5	34
98	5	10	9	12	5	41
99	8	8	10	13	7	46
2000	8	11	9	2	0	30
2001	8	7	8	1	7	31
2002	10	4	13	7	2	36
2003	7	6	8	7	0	28
Total	240	333	334	194	93	1194
Average	7.27	10.1	10.12	5.88	2.81	36.18

Table 4 : Block wise area and annually roof top rainwater harvested from CAET building

Sr. No.	Location of CAET building	Area of roof, m^2	Roof top rainwater harvested annually, m^3
1.	Half side of 'C' block (North side)	862.75	545.30
2.	IDE Space	685.50	433.24
3.	Volley ball ground	1740.00	1099.70
4.	FPM space	1212.00	765.98
5.	Part of A block (South side)	342.75	216.62
6.	G block	560.00	353.92
Total		5,403.00	3,414.76

of daily rainwater from 862.75 m^2 area estimated to be 27m^3. Thus capacity of recharge pit should be 27 m^3. Instead of constructing one recharge pit of 27 m^3 volume it is proposed to construct three recharge pit at 27m apart from each other. First recharge pit is 18 m apart from corner of C block (North side) on upstream side.

Appendix A

Year	June			July		
	< 40 mm	>40 mm		< 40 mm	>40 mm	
		Collected	overflow		Collected	overflow
71	43.5	40	1.0	42.2	-	-
72	107.4	-	-	94.5	-	-
73	68.8	40	4.2	203.6	40	43.7
74	42.0	-	-	78.0	120	43.2
75	57.4	40	44.5	104.3	40	0.8
76	83.0	-	-	173.1	80	13.3
77	90.1	120	116.2	196.4	40	0.4
78	73.6	80	4.0	173.8	120	105.0
79	42.6	120	24.2	120.7	-	-
80	131.1	40	65.6	95.6	40	45.4
81	115.2	-	-	151.6	40	17.2
82	24.2	-	-	97.0	80	79.6
83	69.0	-	-	170.0	80	8.7
84	92.4	-	-	58.0	40	6.4
85	43.0	80	149.2	191.6	40	18.2
86	95.9	40	2.0	92.1	80	19.7
87	164.5	40	30.2	97.3	-	-
88	62.5	120	25.4	206.1	40	146.4
89	104.9	40	9.2	115.0	-	-
90	70.6	160	108.4	78.2	80	73.2
91	100.6	40	9.2	137.5	40	16.8
92	88.8	80	49.2	61.0	-	-
93	88.3	80	26.0	104.2	120	68.4
94	92.6	40	8.0	141.2	120	68.2
95	54.8	-	-	146.5	120	57.4
96	24.4	-	-	116.2	-	-
97	49.2	40	131.2	114.4	-	-
98	52.7	40	3.2	114.0	40	10.4
99	98.8	80	13.0	80.8	40	17.4
2000	102.3	-	-	109.2	80	37.1
2001	98.0	80	26.5	89.2	-	-
2002	70.5	80	90.1	53.4	-	-
2003	75.6	-	--	66.7	-	-
	2578.3 (51.17%)	1520 (30.16%)	940.7 (18.67%)	3873.4 (59.89%)	1520 (23.5%)	1074.2 (16.61%)
Total		5039			6467.6	

Rainwater passes through six drain pipes of area is directed to recharge pit though field channel and from three drain pipes water collected in recharge pit directly. Each recharge pit is having 9 m length, 1 m width and 1m depth thus capacity of recharge pit is 9 m^3.

Considering the average annual rainfall of the area as 790 mm and runoff coefficient of cement concrete as 0.80. The annual volume of rainwater collected and recharge though three pits is 545.3 m^3. The cost of constriction per recharge pit, cleaning and filling to it and formation of bund on upstream side, to guide and direct the flow are Rs. 500/-, Rs. 200/-, and Rs. 100/- respectively. Thus the total cost of construction for one recharge pit is Rs. 800/-. Total cost of three recharge pit constructed for C block (north side) total cost comes to Rs. 2400/-

IDE space:

The water harvested in this space from the roof area of half section of IDE (Irrigation and Drainage Engg.) lab (south side) which is part of C block, Dean's cabin, committee room, office and half portion of varandha (part of A block)

The roof area of half section of IDE lab (south side)

is (30m x 10m + 28.5m x 1.5m) 342.75 m^2 and Dean's cabin committee room, office and half portion of varandha is also same *i.e.* 342.75m^2. The estimated total volume of water harvested and recharge annually from this space is 433.24 m^3, considering average annual rainfall as 790 mm and runoff coefficient of cement concrete as 0.80. The storage tank is in existence in this space. Having capacity 50.4 m^3 (6m x 6m x 1.40 m). It is proposed to divert water to filled the storage tank excess water is recharge as there is sufficient space for recharging.

Volley ball ground:

The water harvested in this space is from the roof area of two lect. hall and some portion of varandha. (part of C block) and complete B block.

The roof area of two lect. Hall and some portion of varandha (part of C block) is 525m^2, one lect. hall and physics lab (part of A block) is 435 m^2 and roof area of B block is 780 m^2. Thus total roof area is 1740 m^2 hence annually water harvested and recharge in this space is 1099.7 m^3. The volley ball ground is of (30m x 30m) *i.e.* 900 m^2 area which is sufficient to recharge the collected amount of runoff above area.

FPM space:

The water harvested in this space from the roof area of D block, F black and E block (half) with its varandha.

The roof area of D block is 507 m^2, F block is 420 m^2 and E block (half) with its varandha is 285 m^2 hence the total area is 1212 m^2. The estimated annual quantity of water drain in this space is 765.98 m^3. For this area to harvest the roof top rain water divert the water directly in the water tank already exist in this space having size (4.5m x 4.5m x 1.25m) thus the capacity is 24.31 m^3 secondly it is proposed to construct a bund near the main gate of FPM (Farm Power Machinery) space to retain and recharge the water.

Part of a block (south side):

The roof area of part of A block (south side) and half varandha is (30m x 10m + 28.5m x 1.5m) 342.75 m^2 the estimated annual quantity of water drain from this roof area is 216. 62 m^3 considering design depth 40 mm and runoff coefficient of cement concrete 0.8. The estimated daily quantity of water drain from this roof area is 11 m^3. It is proposed to construct a recharge pit on downstream side along length of size (11m x 1m x 1m) thus the capacity is 11 m^3. The water from drain pipes diverted towards the recharge pit though field channel.

'G' block:

The roof area of 'G' block have 28 m length and 20 m with thus the total area is 560 m^2 and annually the volume of water harvested from this roof area is 353.92 m^3. Here around every drain pipe construction is already made for recharge the rainwater from the roof area of 'G' block.

Estimated annual rainwater harvested from CAET building:

The details about block wise area and estimated roof top rainwater harvested annually is given in Table 4. The total area of the CAET building is 5403m^2 and the estimated annual volume of water recharge from this area is 3414.76m^3.

Conclusion:

Important conclusions drawn from above studies are as fallows.

– The average daily rainfall during *Kharif* season below 40 mm is 56.83 %.

– Out of total rainfall average daily rainfall above 40 mm during *Kharif* season is 43.17%, from which 25.75% can be collected in recharge pit if we design pit considering 40 mm depth.

– 82.58% of the total rainfall will be collected in recharge pit if we design pit considering 40mm rainfall depth.

– The average numbers of rainy days at Akola during *Kharif* season are 36.18.

– Recharge cost/m^3 for half of C block (North side) is Rs. 0.88/-

– Annually water recharge from roof area of CAET building at Akola is 632 lit/m^2 of slab.

– The total area of CAET building is 5,403 m^2 and the estimated annual volume of water recharge from this area is 3,414.76 m^3.

Authors' affiliations:
V.G. NIMKALE, International Horticulture Innovation and Training Centre, JAIPUR (RAJASTHAN) INDIA
S.B. JAJOO, Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, AKOLA (M.S.) INDIA

REFERENCES

Mehta, M., Marwaha, S. and Singh, Dalel (2000). Artificial recharge to groundwater in alluvial tracts of Northern India. Proc. National Seminar on Rainwater harvesting, CGWB, New Delhi. May 22-23, 2000 : 80-96.

Murthy, D.S.S., Keerthisealan, K. and Sooryanarayanan, K.R. (2000). Rainwater harvesting for augmenting groundwater resources in Karnataka – an overview. Proc. National Seminar on Rainwater harvesting, CGWB, New Delhi. May 22-23, 2000 : 186-204.

Rao and Mohan, M. (2000). Roof water harvesting – effective solution to combat water crises in Dewas. Proc. National Seminar on Rainwater harvesting, CGWB, New Delhi. May 22-23, 2000 : 118-130.

Taneja, D.S. and Aggrawal, Rajan (2003). Sustainable technology for rainwater harvesting through rooftop for artificial groundwater recharge. Proceedings of national Conference on Integrated Sustainable Water Resources Planning and Management October 11-12, 2003. Birla Institute of Technology and Science, Pilani : 323-329.

***