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Quantification of Percolation from Percolation Tank

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ABSTRACT

Uncertainty in the occurrence of rainfall with respect to time and quantity is a major constraint to agricultural production in rainfed areas. To alleviate the constraint, groundwater is pumped at an unsustainable rate causing continuous water table decline. Groundwater recharge by the rainwater and runoff harvested in percolation tanks can augment the groundwater resource. A study was conducted to quantify percolation from a percolation tank by using water balance approach. The study revealed that the rate of percolation varied from 177.30 to 12.049 m^3 per day (48.43 to 2.86 mm/day) during monsoon season when the tank storage varied from 9960 to 5150 m^3. In the spring season, the percolation rate varied from 91.78 to 3.067 m^3 per day (18.40 to 0.67 mm/day) for tank storage between 3740 and 390 m^3. The average rate of percolation over an observation period of 217 days was 39.517 m^3 per day. Out of total storage loss of 13620.92 m^3 from the tank over an observation period of 217 days, 8615.51 m^3 water was lost through percolation and the rest 5005.41 m^3 through evaporation. Thus, about 63 per cent of the water loss from percolation tank storage is a gain to the groundwater resource.

INTRODUCTION

The population of India is likely to become 1.40 billion by 2025 AD and 1.60 billion by 2050 AD, and that would require about 380 million tons and 450 million tons, respectively, of food grain annually at the present level of per capita consumption. This in turn would make it necessary to irrigate about 150-160 million hectares as against the currently irrigated area of about 90 million hectares (Mohile, 2000).

Over the years ground water has become an important resource to supplement the surface water resource for meeting the crop water demand. As a result, groundwater has been overexploited resulting into continuous decline of water table in various parts of the country. Groundwater can be augmented through artificial recharge. The rechargeable monsoon surplus water is estimated as 87 million hectare meters (Gupta et al 2000).

Among several techniques, recharging groundwater through seepage from a percolation tank is a potential option. Such recharge can be quantified through water balance study.

With the above background, a detailed water balance study was carried out for the percolation tank located 20 km away from Narsinghpur district head quarter in Madhya Pradesh with the specific objective to quantify percolation losses from the tank.

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MATERIALS AND METHODS

The tank was constructed by the Madhya Pradesh State Agriculture Department in the year 1991 to create storage of surface water, which could be recharged to the groundwater reservoir. A catchment area of 0.402 km^2 drains into the tank. The tank specifications are as follows:

Full tank level, m	:	98.50
Capacity at full tank level, m^3	:	99110
Maximum water level, m	:	99.10
Top bund level, m	:	100.30
Lowest level, m	:	97.05
Length of bund, m	:	345
Maximum height of bund, m	:	3.19
Top with of bund, m	:	3.00
Width of waste weir, m	:	15.00

The water level was noted daily at 7 AM by using a staff gauge fixed in the tank. The gain in tank water level was due to inflow of runoff, direct rainfall and seepage from higher reaches. The decline in the tank water level was due to percolation and evaporation only, as no water was withdrawn for use. Since the quantum of percolation from a tank can not be measured directly, it was estimated through water balance calculation by using the following equation (Taygi,2000):

Inflow – outflow = Change in tank storage.

or

$$(Is + Ir) - (E + Lp) = Ä\ S$$

Where,

Is = Inflow to the tank due to surface flow.

Ir = Direct addition to tank storage from rainfall.

E = Evaporation.

Lp = Losses due to percolation.

DS = Change in tank storage.

All the above quantities are the volume of water in cubic meter over a specified period of time.

In the water balance calculation, the storage in the tank and its water spread area were computed corresponding to the recorded water stage by using the stage-capacity and stage-water spread area curves. The inflow terms Is and Ir were computed jointly as total addition in the tank through increase in tank stage. The average daily pan evaporation data of the 29 years (1967 to 1996) was collected from the All India Co-ordinated Research Project on Agro-meteorology, College of Agricultural Engineering, JNKVV, Jabalpur and the evaporation from the percolation tank was taken as 0.7 times the observed pan evaporation (Anonymous 2000). The daily rainfall was recorded at percolation tank site by non-recording rain gauge.

RESULTS

Inflow components

The period for recording observation, in monsoon season was spread over 17 weeks from 2nd July to 28th October 2000. The weekly changes in staff gauge readings were calculated from the daily-recorded data to compute the inflow to the tank. During the study there was no overflow from the waste weir, hence the change in stage corresponded to the direct rainfall over the tank and surface inflow from the catchment area. The water balance of percolation tank is presented in Table.1. The total inflow during monsoon season was 9477.1 m^3. The maximum inflow (2996 m^3) was noticed in the 30th standard week, and inflow ceased to zero from 39th week onwards as rain withdrew on 22nd September. In the spring season very little (130.8 m^3) inflow took place (Table 2).

Outflow components

Evaporation from the tank water surface and percolation from the tank were the two outflow components.

Table 1. Water balance of percolation tank for Monsoon season

Sl No & SMW	7-day periods in 2000	Change in tank stage (m)	Change in tank storage (cu.m)	Addition to tank (rainfall+ runoff) (m^3)	Loss from tank storage (m^3)	Actual Evapo-ration (cu.m) **	Percolation (m^3)	Percolation (m)	Percolation rate (m^3/day)	Percolation rate (mm/day)	Evapo-ration (%)	Perco-lation (%)
(1)	(2)	(3)	(4)	(5)	(6)=5-4	(7)	(8)=6-7	(9)=(8*3)/4	(10)=8/ days of col.. 2	(11)=9/ days of col. 2	(12)= (7/6) ×100	(13)= (8/6) ×100
1, 27	Jul. 2-8	+0.19	+810.00	1280.00	470.00	212.30	257.70	0.060	36.814	8.57	45.17	54.83
2, 28	Jul. 9-15	-0.07	-240.00	22.50	262.50	178.16	84.34	0.020	12.049	2.86	67.87	32.13
3, 29	Jul. 16-22	+0.32	+1260.00	1753.20	493.20	209.70	283.50	0.072	40.500	10.29	42.52	57.48
4, 30	Jul. 23-29	+0.80	+2480.00	2996.00	516.00	214.00	302.00	0.097	43.143	13.86	41.47	58.53
5, 31	Jul. 30-Aug. 5	-0.30	-810.00	0.00	810.00	149.65	660.35	0.245	94.357	35.00	18.48	81.52
6, 32	Aug. 6-12	-0.28	-890.00	226.00	1116.00	179.60	936.40	0.295	1.33.77	42.14	16.09	83.91
7, 33	Aug. 13-19	-0.12	-420.00	75.80	495.80	190.80	304.97	0.087	43.567	12.43	38.48	61.52
8, 34	Aug. 20-26	-0.15	-550.00	80.00	630.00	169.40	460.60	0.126	65.800	18.00	26.89	73.40
9, 35	Aug. 27-Sep.2	+0.15	+550.00	1970.00	1420.00	178.90	1241.10	0.339	177.300	48.43	12.60	87.40
10, 36	Sep.3-9	+0.10	+350.00	950.50	300.50	199.20	381.30	0.109	54.47	15.57	66.29	33.71
11, 37	Sep.10-16	-0.10	-350.00	59.10	409.10	204.60	204.50	0.058	29.214	8.29	50.01	49.99
12, 38	Sep.17-23	-0.08	-280.00	64.00	344.00	211.40	132.60	0.038	18.943	5.43	61.45	38.55
13, 39	Sep.24-30	-0.10	-380.00	0.00	380.00	202.70	177.30	0.047	25.329	6.71	53.34	46.66
14, 40	Oct. 1-7	-0.08	-310.00	0.00	310.00	185.50	124.50	0.032	17.786	4.57	59.84	40.16
15, 41	Oct. 8-14	-0.12	-490.00	0.00	490.00	185.80	304.20	0.075	43.457	10.71	37.92	62.08
16, 42	Oct. 15-21	-0.12	-510.00	0.00	510.00	173.60	336.40	0.079	48.057	11.29	34.04	65.96
17, 43	Oct. 22-28	-0.10	-430.00	0.00	430.00	134.00	296.00	0.069	42.286	11.50	31.16	68.84
Total				9477.1	9387.1	3179.31	6207.79		52.61		33.87	66.13

Total days in this season: 118

** Pan evaporation x 0.7 (Pan coefficient) x water spread area.

Table 2. Water balance of percolation tank for spring season

Sl No & SMW	7-day periods in 2001	Change in tank stage (m)	Change in tank storage (m^3) *	Addition to tank (rainfall+ runoff) (m^3)	Loss from tank storage (m^3)	Actual Evapo-ration (cu.m) **	Percolation (m^3)	Percolation (m)	Percolation rate (m^3/day)	Percolation rate (mm/day)	Evapo-ration (%)	Perco-lation (%)
(1)	(2)	(3)	(4)	(5)	(6)=5-4	(7)	(8)=6-7	(9)=(8*3)/4	(10)=8/ days of col.. 2	(11)=9/ days of col. 2	(12)= (7/6) ×100	(13)= (8/6) ×100
18, 5	Feb. 2-4 (3 days)	-0.01	-50.0	0	50.0	40.8	9.2	0.002	3.067	0.67	81.60	18.40
19, 6	Feb. 5-11	-0.03	-122.45	0	122.45	103.3	19.15	0.005	2.736	0.71	84.36	15.64
20, 7	Feb. 12-18	-0.01	-50.0	87.8	137.8	108.7	29.1	0.006	4.157	0.86	78.88	21.12
21, 8	Feb. 19-25	-0.04	-200.0	0	200.0	123.0	77.0	0.015	11.0	2.14	61.50	38.50
22, 9	Feb. 26- Mar. 4	-0.04	-210.0	0	210.0	133.4	76.6	0.015	10.94	2.14	63.52	36.48
23, 10	Mar. 5-11	-0.04	-210.0	0	210.0	134.4	75.6	0.014	10.8	2.00	64.00	36.00
24, 11	Mar. 12-18	-0.05	-260.0	0	260.0	147.6	112.4	0.023	16.057	3.29	56.77	43.23
25, 12	Mar. 19-25	-0.05	-260.0	0	260.0	151.6	108.4	0.021	15.486	3.00	58.31	41.69
26, 13	Mar. 26- Apr. 1	-0.07	-270.0	0	370.0	157.3	112.7	0.029	16.1	4.14	42.51	57.49
27, 14	Apr. 2-8	-0.04	-220.0	0	220.0	158.0	62.0	0.011	8.857	1.57	71.82	28.18
28, 15	Apr. 9-15	-0.07	-380.0	0	380.0	153.4	226.6	0.042	32.37	6.0	40.37	59.63
29, 16	Apr. 16-22	-0.05	-280.0	43.0	323.0	143.0	180.6	0.032	25.800	4.57	44.27	55.73
30, 17	Apr. 23-29	-0.05	-290.0	0	290.0	128.6	161.4	0.028	23.057	4.00	44.31	55.69
31, 18	Apr. 30- May 6	-0.09	-520.0	0	520.0	101.9	418.1	0.072	59.729	10.29	19.60	80.40
32, 19	May 7-11 (5 days)	-0.10	-500.0	0	500.0	41.1	458.9	0.092	91.78	18.4	8.22	91.78
Total				130.8	4233.82	1826.1	2407.72		24.32		43.13	56.87
Over all Total			-4013.02	9607.90	13620.92	5005.41	8615.51		39.70		36.75	63.25

Total days in this season: 99; Total days in two seasons: 217.

** Actual evaporation = Pan evaporation ′ 0.7 (Pan coefficient) ′ stage spread area.

Evaporation from the tank

Evaporation was maximum (214 m^3) in the 30th week, closely followed by 212.3 m^3 in the 27th week and 211.4 m^3 in the 38th week. It decreased from 38th week onwards. The seasonal evaporation was 3179.31 m^3, which was 33.87% of the total seasonal water loss (Table 1) in the monsoon season.

During the spring season the maximum evaporation (158 m^3) was noticed in the 14th week. Total evaporation loss during the spring season was 1826.1 m^3, which was 43.13% of total water loss in this season. Overall 5005.41 cum water loss was due to evaporation, which was 36.75% of total water loss.

Percolation from the tank

During the monsoon season, percolation loss varied from 1241.1 to 84.34 m^3 at a corresponding rate of 177.3 to 12.049 m^3/day, for storage in the percolation tank ranging between 9960 and 5150 m^3 (Table1). During the spring season, percolation loss varied from 458.9 to 9.2 m^3 at the corresponding rates of 91.78 and 3.667 m^3/day for storage in the percolation tank ranging between 3740 and 390 m^3.

CONCLUSIONS

Based on the study carried out the following conclusions were drawn.

1. The rate of percolation varied from 177.3 to 12.049 m^3/day (48.43 to 2.86 mm/day) for tank storage from 9960 to 5150 m^3 during the monsoon season and it varied between 3.067 to 91.78 m^3/day (0.67 to 18.4 mm/day) for tank storage of 390 to 3740 m^3, during the spring season.
2. The average rate of percolation over a total observation period of 217 days was 39.521 m^3/day.
3. A total of 13620.92 m^3 of storage loss occurred from the tank over a period of 217 days. This comprised 8615.51 m^3 of percolation loss and 5005.41 m^3 of evaporation loss.

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