International Journal of Hydraulic Engineering 2018, 7(1): 11-14
DOI: 10.5923/j.ijhe.20180701.02

Determination of Conveyance Loss through Earthen Channel by Cutthroat Flume

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Abstract The conveyance efficiency in irrigation projects is poor due to seepage, percolation, cracking, and damaging of the earth channel. Seepage loss in irrigation water conveyance system is very significant, as it forms the major portion of the water loss in the irrigation system. The purpose of this study was to determine the conveyance losses of irrigation water through earthen channel. A 50ft long and straight earthen channel was selected for this purpose. It was modified by excavation and compaction and also by maintaining suitable bed slope and side slopes. In this experiment discharge was measured by Inflow-Outflow method using cut-throat flumes. It can be seen from the results that conveyance losses were found to be 40.01%, 35.42%, 32.81% and 4% under natural condition, compacting the sides and bottom, using lining material of cow dung and rice husk mixture ratio 1:1 and polythene sheet, respectively. The results also indicated that lining material reduced conveyance loss to a great extent followed by compaction and natural conditions. It may be inferred that the mixture of cow dung and rice husk could be used as lining material because it is easily available, low cost and even unskilled labor can make it. Finally it could be used for reducing water losses through earthen channel.

Keywords Conveyance loss, Earthen channel, Cutthroat flume

1. Introduction

Irrigation is an important factor in our agricultural sector due to uncertainty of weather of Bangladesh. Water is vital for agriculture and where there is a lack of water, irrigation is only the way to make up it. Growth in crop production in the country primarily depends on the irrigation development. But the irrigation is hampered by the irrigation water losses. The optimum use of irrigation water should be an important strategy for increasing agricultural production in Bangladesh. Recently much attention has been given to improving the performance of existing irrigation systems instead of building new irrigation systems. Water losses by -seepage, dead storage, percolation, evaporation, overtopping occurred by improper design, alignment, construction and maintenance of irrigation channel. The conveyance loss ranged from 15 to 50 % of the total water supply (Dutta, 1982). The rapidly increasing value of water is commanding new interest in the development of new open channel flow measuring devices. The most common measuring flume is the Parshall flume developed by Ralph Parshall (1926) at Colorado State University. Water measuring devices are important for water conservation, equitable distribution of water, determining the amount of available water, meeting legal requirements and successful management of the available supply. A flow measuring device which has been recently developed is the Cutthroat flume (Skogerboe, Hyatt, Anderson, and Eggleston, 1967) was used for this experiment.

Khair and Hossain (1978) and Khair *et al.,* (1980) observed one fourth of all water diverted for irrigation purpose at various places in Bangladesh is lost in conveyance through the unlined earthen channel where seepage accounts to high rates to various socio-technical reasons. Miah (1984) from five deep tube well irrigation projects located in Dhamrai observed that on the average 27% of the pumped discharge was lost in the earthen channel. He highlighted that this loss was due to seepage through poorly sealed outlets. A collaborative research has some indication about the compaction of earthen channel that could reduce conveyance losses to about 34% but the author failed to mention the range of compaction or the level of moisture content at which the channel sub-grades were compacted.

Growth in crop production in the country primarily depends on the irrigation development. Due to absence of adequate surface water in the dry season, irrigation is heavily dependent on groundwater. With the increased in groundwater use and expansion of irrigated area, inefficient water distribution and inadequate supply limit crop growth in irrigated fields. Therefore, the determination of conveyance loss through earthen channel was important for proper

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Published online at http://journal.sapub.org/ijhe

on-farm water management and perfect utilization of water resources in our country.

2. Methodology

A field experiment was conducted in a field at the southeast side of Central Mosque, Hajee Mohammad Danesh Science and Technology University, Dinajpur. Topography of the farm land was relatively high and flat (0-5% slope). The district has a distinct monsoonal season. The average rainfall of the study area was less (197.9 cm) than average rainfall (203cm) in Bangladesh. Temperature was moderately high (35°C) in summer and moderately low (10°C) in winter. The soil of the study area was considered to be the best agricultural productive soil in the country. Texturally the soil was sandy loam. The percentage of sand, silt, and clay is 46.2%, 36.6%, and 17.2% respectively. The particle size analysis of soil was done by hydrometer method. The soil sample was analyzed by hydrometer method in HSTU soil science laboratory. The cutthroat flume used for this purpose was standard in size that was length = 2ft, height = 1ft, width = 0.79ft, throat = 0.33ft. Water losses through the earthen channels while conveying it from the source to the fields in irrigation project conveyance and distribution losses mainly occur. For this experiment inflow-outflow method was selected. The difference between the quantity of water entering the reach & the quantity of water going out of that reach give an amount of water lost. The cut throat flume was used for measuring flow using inflow-outflow method. A 50ft long but straight earthen channel was selected for this purpose. The water loss of respective channel was measured by cut throat flume under four conditions: natural condition, compaction by durmus, mixture of cow dung and rice husk, polythene sheet. In this experiment the following materials were used: flume, measuring tape, meter scales, stop watch, spirit level, spade, polythene sheet, piece of wood, lining materials, paper, pencil etc. The flow in the irrigation channel may be either free flow or submersed flow depending on transition submergence. When the flow was free discharge was measured by Skotgerboe equation:

$$Q = C_1 h_a^{n_1} \quad (1)$$

Where, Q = Flow rate in cfs, C_1 = Free flow co-efficient, h_a = Upstream flow rate in ft, n_1 = Free flow exponent and C_1 = k1w1.025 where, k_1 = Flume length co-efficient, w = Throat width in ft. When the flow was submerged, the following equation was employed to find the discharge:

$$Q = \frac{C_2(h_a - h_b)n^1}{(-\log S)n^1} \quad (2)$$

Where, C_2 = Submerged flow co-efficient, n_1 = Free flow exponent = 1.98 (for flume length=2 ft), n_2 = Submerged flow exponent, h_a = Upstream flow depth in ft, h_b= Downstream flow depth in ft, S = Degree or percentage of submergence. For submerged flow S =0.65 to 0.90 and for free flow S is less then 0.65.

The conveyance loss was measured by:

$$C_L = \{\frac{Q_1 - Q_2}{L}\} \times 100 \quad (3)$$

Where, C_L = Rate of conveyance loss in the channel, Q_1 = Rate of flow at the inlet in cfs, Q_2 = Rate of flow at the outlet in cfs, L = Distance between two points.

The following steps were maintained to determine the conveyance loss from the earthen channel: Two individual flumes were set with proper leveling at suitable positions keeping distance of 50 ft from one another, the outer portion of the channel in each section was blocked with clay soil so that water could pass only through the flume, first readings were taken before compacted the channel, then cracks & holes of the channels were field with mud &compacted channel with wooden block, after taking reading under compaction channel was labeling with lining materials (cow dung and rice husk) & then readings were taken, polythene sheet was put on channel, experimental readings were taken from the channel one after one, experimental data were tabulated &discharges were calculated, the three replications were taken.

3. Results and Discussion

The results at different points in irrigation channel at different conditions as well as percent conveyance losses were presented in tables 1, 2, 3 and 4 respectively. In natural condition, water loss was too high because existing grass retained water so that percolated water was high and insufficient canal capacity so that some water over topped and lateral movement was also more.

Under compacted condition of channel the average conveyance loss was found 35.42% (Table 2). This loss was less than that of channel under natural condition. This is in agreement with the findings of Moghazi and Ismail (1996) who reported that compacted the canal bed may be reduced the rate of seepage to a reasonable extent. But using a mixture of cow dung and rice husk as a lining material the average conveyance loss was found 31.81 % (Table 3). This loss was less than the channel under natural and compacted conditions because percolation and lateral movement of water were less. Similarly for using polythene sheet the average conveyance loss was found 4 % (Table 4). This happened because there had no percolation and lateral movement of water. Polythene sheet may be used when the cost of water loss is higher than the cost of polythene sheet.

Table 1. Conveyance loss under natural condition

	1st flume			2nd flume			
Time recorded	**ha (in)**	**Discharge (cfs)**	**Average discharge (cfs)**	**ha (in)**	**Discharge (cfs)**	**Average discharge (cfs)**	**Conveyance loss (%)**
11:04 am	6.8	0.55		5.4	0.34		
11:14 am	6.9	0.56	0.56	5.4	0.34	0.34	40.01%
11:24 am	6.9	0.56		5.5	0.35		

Table 2. Conveyance loss under compaction

	1st flume			2nd flume			
Time recorded	**ha (in)**	**Discharge, Q (cfs)**	**Average discharge (cfs)**	**ha (in)**	**Discharge, Q (cfs)**	**Average discharge (cfs)**	**Conveyance loss (%)**
2:10 pm	6.4	0.47		5.1	0.31		
2:20 pm	6.6	0.51	0.48	5.2	0.32	0.31	35.42
2:30 pm	6.4	0.47		5.2	0.32		

Table 3. Conveyance loss using mixture of cow dung & rice husk as a lining material

	1st flume			2nd flume			
Time recorded	**ha (in)**	**Discharge, Q (cfs)**	**Average discharge (cfs)**	**ha (in)**	**Discharge, Q (cfs)**	**Average discharge (cfs)**	**Conveyance loss (%)**
10:50 am	6.2	0.45		5.0	0.29		
11:00 am	6.1	0.43	0.44	5.1	0.31	0.30	31.81
11:10 am	6.1	0.43		5.0	0.29		

Table 4. Conveyance loss using polythene sheet

	1st flume			2nd flume			
Time recorded	**ha (in)**	**Discharge, Q (cfs)**	**Average discharge (cfs)**	**ha (in)**	**Discharge, Q (cfs)**	**Average discharge (cfs)**	**Conveyance loss (%)**
2:00 pm	6.5	0.50		6.3	0.48		
2:10 pm	6.5	0.50	0.50	6.3	0.48	0.48	4.0
2:20 pm	6.5	0.50		6.3	0.48		

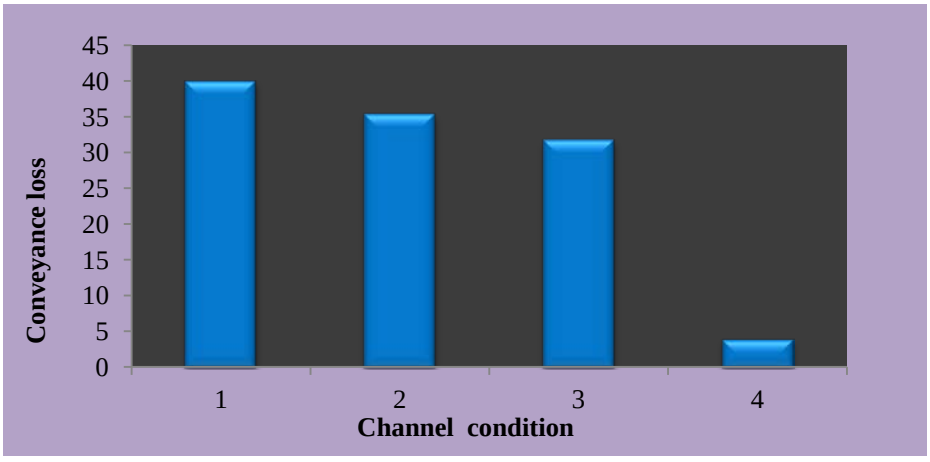

Figure 1. Conveyance loss bar diagram

Here,
Channel condition-1 =Natural condition
Channel condition-2 =Compacted condition
Channel condition-3 =Using lining materials
Channel condition-4 =Polythene sheet

This curve showed that conveyance loss under different channel conditions-natural condition, compacted condition, using lining material and polythene sheet was 40.01%, 35.42%, 31.81%, 4.0% respectively. From the diagram it was found that the conveyance loss was less when using polythene sheet.

4. Conclusions

The conveyance loss was too high in natural condition. In compacted condition it was required highly maintenance of compaction level in irrigation channel and human drudgery. On the other hand, using lining materials reduced loss and it was economical. When using polythene sheet, the conveyance loss was less. But it was not economical and conveyance harmful for environment. That is why; using lining materials were suitable for minimizing conveyance loss.

REFERENCES

[1] Dutta, S. C. 1982. Some aspects of irrigation Management in Selected areas, IN: Biswas, M. R. and M.A.S. Mondal (ed) "On-Farm Irrigation Water Management Problems". Bureau of Socio-economics Research and Training BAU, Mymensingh, pp. 99-108.

[2] Skogerboe Gaylord, S.B. and R.W. Wynn. 1973. Selection and installation of cutthroat flume for measuring Irrigation and drainage water pp. 1-20.

[3] Khair, A and M. Hussain. 1978. Lows cost lining for irrigation canal. J. Agril Mech. In Asia, Africa and Latin America (AMA), pp.90-120.

[4] Moghazi, H.E.M and E.S. Ismail. 1996. A study of losses from field channel under and region conditions. Agricultural Engineering Department, Faculty of Agriculture and Veterinary Medicine, King Saud University, Buriadah Saudi Arabia, pp.40-44.

[5] Miah, M.M. 1984. Improvement of deep tube well irrigation problem in Bangladesh. A dissertation (Doctor of Philosophy), Utha state university, Logan, Utha, U.S.A, pp.39-46.

[6] Michael, A.M. 1978. Irrigation Theory and Practice. Vikas Publishing House Pvt. Ltd. New Delhi, India, pp.300-306.