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Distribution System of Irrigation Water in Bangladesh: A Case Study of Bangladesh Agricultural University Farm

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Abstract

A study was conducted at Bangladesh Agricultural University (BAU) farm in 2010 to evaluate the irrigation water distribution system and determine the conveyance losses of both the lined and unlined irrigation canals. There were 3 Deep Tubewells (DTWs) in 3 blocks at BAU farm mainly used for irrigation purposes. The capacity of DTWs and conveyance losses were measured using cutthroat flume and verified using float method. The discharge of the DTWs were measured at the delivery points and found to be 1.5, 1.3 and 1.2 cusec in DTW_1, DTW_2 and DTW_3 respectively. Efficiency of the DTWs was 75, 65 and 80% respectively. The total length of lined canals in the farm was 1256 m, 1913 m and 640 m and total length of unlined canals was 870 m, 3100 m and 850 m under block no. 1, 2 and 3 respectively. The conveyance losses of lined canal considering a length of 50 m were 1.06%, 3.85% and 8.3% and the same for unlined canals was 12.5%, 33.33% and 37.9% under block no. 1, 2 and 3 respectively. In terms of volume the conveyance losses for unlined canals considering a length of 50 m were 3.49, 6.45 and 8.51 m^3/m^2/day under block no. 1, 2 and 3 respectively.

Keywords: *Conveyance loss, discharge, distribution system, lined canal and cut throat flume.*

1. Introduction

Abundance of water during monsoon and its scarcity during rabi season severely restrict agricultural production in Bangladesh. Therefore, planned utilization and efficient management of water resources particularly through irrigation is considered as one of the most crucial elements for increasing area under cultivation and improving long term productivity and employment. Irrigation is considered as the leading input for enhancing agricultural production since irrigation makes dry season crops and it increases wet season yields by establishing a more favorable water regime for crops. Further, it induces to invest in other inputs, such as high yielding seeds, fertilizers and additional labor by reducing the risks of loss these investments from drought. Irrigation in sum provides the stage on which all other yield increasing inputs perform their roles (Rogers *et al*., 1989). Application of water to the cultivated land is one of the major measures.

Ground water source used by the installation of DTW and STW made a revolutionary change in agricultural sector to save the country from chronic food deficit. Ground water is the principal and most widely distributed resources for irrigation. For irrigation purposes Bangladesh abstracts 86% water from underground sources for irrigation and rest 14% of total abstraction use in domestic and industry (Margat and Van der Gun, 2013). Ground water exploitation and utilization have become important throughout the country as water use in agriculture is increasing. Like other natural resources, water is becoming a scarce resource in many parts of the world. If misused, shortage of water may lead to far-reaching consequences. Though Bangladesh has abundant water resources, it is unequally distributed over the year as well as over the region (Rashid, 1991). But groundwater irrigation potential is largely in the west and north of the country and most of the remaining regional river potential is in the south-central region. However, drying of wells during the dry season in certain areas of Northern region proved that ground water resources also need to be used judiciously (Jaim, 1993). Bangladesh has 8.54 million hectare cultivable land of which only 61% is under irrigation with groundwater (79%) and surface water (29%) (BADC, 2013). With the shortage of water in dry season, we have to increase production utilizing this water. Command area is an important factor in irrigation water distribution. In order to increase irrigation efficiency, command area development is essential factor. In Bangladesh command area under a DTW is very low as compared to desire one.

The main cause of this is conveyance loss of water. Conveyance losses were found to be 41%, 48% and 45% in existing earthen canals at Mithapukur, Manikganj Sadar and Dhamrai respectively (Sayed, 2010). Most of the farm has a poor canal system, especially earthen canal which has a large conveyance loss. Maniruzzaman *et al.,* 2002 reported that the conveyances loss was 2.8 to 9.5% in PVC and plastic pipe whereas in earthen channel it varied from 30 to 33% in silty-clay loam soil. In order to irrigate the whole cultivable land we need to improve irrigation water distribution system and develop command area. Due to scarcity of water in dry season the optimum use of irrigation water should be an important strategy for increasing agricultural production in Bangladesh. The country will realize sustainable benefit if the allocation and distribution of the available water are improved. Field studies are needed to identify the nature and magnitude of water management, which would help to achieve higher crop yields, higher irrigation efficiencies and greater water distribution equality. This study aims to evaluate the water distribution system of BAU farm and also determine the conveyance losses of water of both lined and unlined canals.

2. Methodology

2.1 Study Area

The study area was Bangladesh agricultural university farm. The area lies between Kotowali thana of Mymensingh district and it is bounded on the east of the river “Old Brahmaputra”. It has a total area of 1200 acres of which about 200 acres are available for cultivation and are irrigated by DTW. The study area lies approximately between 24˚36´ to 24˚54´ west latitude and between 90˚15´ to 90˚30´ east longitude. The topography of the land was high. It included mainly the “Old Brahmaputra” flood plain. The texture of the soil was clay loam to silty clay loom. Color of the soil was generally gray. The soil of the study area was considered to be the best agricultural productive soil in the country. The climate of this area was mainly tropical and tends to remain mild throughout the year.

2.2 Discharge of DTW

The rate of flow passing through a section is termed as discharge. Discharge of DWT was measured using Cutthroat flume of size (3ft×4inch) and verified it using Floating method.

Cutthroat flume: The cutthroat flume is an attempt to improve on the Parshall flume, mainly by simplifying the construction materials. The details of the flume are shown in Fig.1 the flume has a flat bottom, vertical walls and a zero length throat section. Since, it has no throat section; it was given the name cutthroat by the developers (Skogerboe *et al*., 1973). The most obvious advantage of a cutthroat flume is economy. Any flume length between 45 cm and 3 m can be used while throat widths between 2.5cm and 1.8 cm have been investigated.

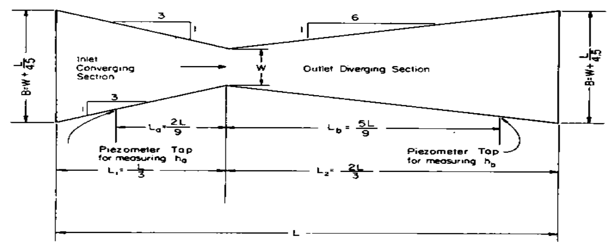

Fig.1: Top view of a cutthroat flume

The cutthroat flume was installed in the canal, the leakage was checked by mud and the flow took place through the flume. When the depth of flume was constant the upstream flow depth “h_a” and down steam flow depth “h_b” were measured from the scale attached to the flume.

The condition of flow (Free flow, submerged flow or not valid) was identified by dividing h_b/h_a ($h_b/h_a \leq 0.65$ for free flow, $h_b/h_a = 0.65$ to 0.90 for submerged flow and $h_b/h_a >$ 0.90 not valid). After identifying the flow condition discharge was calculated with the value of h_a and h_b for the flume size 4"×3' (By using equation (1) for submerged flow and equation (2) for free flow.)

Under submerged flow conditions flow rate Q was determined by the following relationship:

$$Q = \frac{KW(h_a - h_b)}{-\log S} \quad \text{........(1)}$$

Where, Q= flow rate (cfs), W = Throat width (ft), h_a = Upstream flow depth (ft), h_b= downstream flow depth (ft), K_2 = Submerged flow flume length co-efficient, n_1 = Free flow exponent, n_2 = Submerged flow exponent.

Under free flow conditions flow rate Q was determined by the following relationship:

$$Q = C_1 h_a^n \quad \text{................(2)}$$

Where, $C_1 = k_1 W^{1.025}$ = Free flow coefficient, k_1 = the flume length coefficient, W = Throat width (ft)

For different size of flume, the flume length coefficient and flow exponent for submerged and free flow conditions are determined (appendix).

Float method: Float method is determined by the distance across to time. If distance is S and time is T then velocity is V = S/T

If "A" be the cross sectional area of the channel then, discharge of the channel is calculated as,

Q = AV…………………(3)

2.3 Conveyance Loss Measurement

Inflow-outflow method: This method is very simple method that consists of measuring the quantity of water going out of that reach. The difference gives the amount of water lost. The discharge can be measured by the help of flume, weir, current meter etc. It is necessary to maintain constant water level and allowance should be made of rainfall and evaporation. The accuracy of the method increase with the difference between the quantity of inflow and outflow rates. In present study two identical cut throat flumes were used to estimate the discharge for the selected canal section. The conveyance loss is calculated by the following formula:

$S = \{(Q_1-Q_2) \div L\} \times 100$

Where, S = rate of conveyance loss in the canal ($m^3/s/100m$), Q_1 = rate of flow at the inlet (m^3/s), Q_2 = rate of flow at the outlet (m^3/s), L = distance between two points (m)

3. Result and Discussion

The total cultivable area of BAU farm was 76.56 hectares (189.11 acres) and was divided into 3 blocks. Amount of cultivable lands were 48.91 hectares (120.8 acres), 10.47 hectares (25.71 acres) and 17.25 hectares (42.60 acres) under block 1, 2 and 3 respectively. There were 3 DTWs to irrigate these cultivable lands. Total length of lined and unlined canals, the discharge and conveyance losses of both lined and unlined canals under these DTWs were determined.

3.1 Distribution system

Irrigation water was conveyed to the field using both lined and unlined canals. Lined canals were well designed. It has proper specification and sufficient freeboard. Total length of lined canals in the farm were 1256 m, 1913 m and 640 m under block 1, 2 and 3 respectively.

Unlined canal existing at BAU farm is not well designed. It was constructed with loose soil with inadequate compaction, insufficient freeboard and irregular canal bed slope. The beds of field canals were mostly lower than the side fields. This is why command area is low. Total length of unlined canals in the farm was 870 m, 3100m and 850 m under block no. 1, 2 and 3 respectively. Unlined canal needs high maintenance and canal bank should be well compacted. The growth of weeds and presence of rodent holes and cracks in the channel body resulted in high conveyance losses.

3.2 Discharge performance of DTWs

Measured discharges of all tube wells (Table 1) at the delivery point were low in compared to the design discharge. Rated discharge of DTW_1 and DTW_2 was 2 cusec, but it yielded 1.5 and 1.3 cusec respectively. Efficiency of DTWs was 75% and 65% respectively. On the other hand DTW_3 discharged 1.2 cusec with rated discharge 1.5 cusec. DTW_3 has highest efficiency of 80% among the three. This result indicated that higher the rated capacity, lower the efficiency. As the efficiency is low power consumption is high in each tubewell.

Table 1. Discharge measurement using cutthroat flume of DTW

DTW	Rated discharge (cusec)	Actual Discharge (cusec)	Efficiency of DTWs (%)
DTW 1	2.0	1.5	75
DTW	2.0	1.3	65
DTW	1.5	1.2	80

3.3 Conveyance losses

Conveyance loss of lined canals (fig. 2) was very low in compared to lined canals (Table 3). Conveyances losses of lined canals ranged from 1.08 to 8.3% and that of unlined canals varied from 12.5 to 40%. The reasons behind high conveyance loss of earthen canals were its poor management, improper design, rodent holes insufficient channel bed slope, over topping the bank etc.

The result is in conformity with the findings of Rahman *et al,* (2010) who reported that conveyance loss of earthen canal under natural condition was found to be 59.06% and that the same after compaction was found 45.75%. Using the mixture of cow dung and rice husk as lining material conveyance loss was found to be 32.55%.

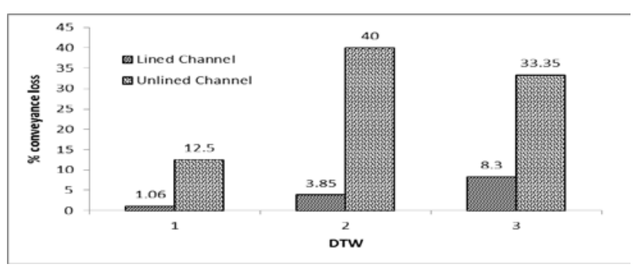

Fig. 2:% Conveyance losses in lined and unlined canals of three DTWs at BAU farm, Mymensingh.

Jadhav *et al*, (2014) reported that the overall efficiency and total loss from the lined, unlined section of canal and unlined field channel under existing condition was obtained as 75, 52 and 35 percent and 0.184, 0.61 and 0.183 Mm^3 respectively in Panchnadi Minor Irrigation Project. These results revealed that management interventions of converting the unlined canal network sections into lined sections can improve conveyance efficiency up to 75% and 0.376 Mm^3 of water can be saved from which about 43 ha additional area can be irrigated.

4. Conclusion

The study revealed that discharge performance of DTWs in BAU farm was low in compared to design ones (65 to 80% of design discharge). Overall conveyance loss of lined canal was acceptable (1.06 to 8.3%). But for unlined canals it was not satisfactory (12.5 to 40.0%). High conveyance loss has reduced command area of DTWs. There is large scope to improve existing command area of a DTW sharply by reducing conveyance loss of irrigation canals. Proper design, regular management, compaction and use of lining materials can reduce the conveyance loss and improve the overall efficiency of the irrigation distribution system of BAU farm. It also save power consumption and human drudgery as well as utilize ground water.

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Apendix 1: conveyance loss measurement in lined canals

Block no.	Flume no.	Distance in m	h_a (m)	h_b (m)	h_b/h_a	Type of flow	ha-h_b	Discharge Q (lit/s)	Water loss (lit/s)	Wetted area (m^2)	Conveyance loss (m^3/m^2/day)	% conveyance loss for 50 m
1	1	50	0.31	0.16	0.51	Free	-	42.76	4.53	50.5	7.75	1.06
	2		0.29	0.07	0.24	Free	-	38.23				
2	1	50	0.29	0.21	0.72	submerge	0.08	36.8	1.4	52.6	2.3	3.85
	2		0.28	0.067	0.24	free	-	35.4				
3	1	43	0.28	0.23	0.82	submerge	0.06	33.98	2.83	41.5	5.86	8.3
	2		0.26	0.12	0.46	free	-	31.15				

Apendix 2: Conveyance loss measurement in unlined canals

Block no.	Flume No.	Distance in m	h_a (m)	h_b (m)	h_b/h_a	Type of flow	ha-h_b	Discharge Q (lit/s)	Water loss (lit/s)	Wetted area (m^2)	Conveyance loss (m^3/m^2/day)	% conveyance loss for 50m
1	1	50	0.23	0.177	0.77	submerge	0.052	22.66	2.83	70.24	3.48	12.5
	2		0.21	0.162	0.77	submerge	0.05	19.82				
2	1	60	0.17	0.063	0.34	Free	-	14.16	5.67	75.81	6.45	40
	2		0.13	0.067	0.52	free	-	8.49				
3	1	44	0.21	0.183	0.87	submerge	0.02	17.0	5.67	57.55	8.51	33.35
	2		0.17	0.155	0.88	submerge	0.02	11.33				