Journal of Engineering and Technology Research Vol. 2(6), pp. 111-117, June 2010
Available online at http://www.academicjournals.org/JETR
ISSN 2006-9790 ©2010 Academic Journals

Full Length Research Paper

A simple mechanical device for the measurement of discharge in a tubewell

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Accepted 24 May, 2010

About 85% of the total water resources are utilized in agriculture. Agriculture is more dependent upon groundwater resources. It is important to know the accurate discharge of the tubewell so that required amount of water may be applied to the field. Presently, Co-ordinate method is the most common method used to measure tubewell discharge, but this is not very accurate. Therefore, to overcome the limitations, an orifice bucket was fabricated and calibrated. It was found that orifices of diameter 11.3, 10, 7.5 and 5 cm measured discharges ranging from 15 -20, 10 -15, 5 -10 and 1 - 5 lps, respectively.

Key words: Tube well discharge, water measurement, orifice bucket

INTRODUCTION

India is having 2% of the world geographical area and 4% fresh water resources. Whereas total population of India is approximately 17% and cattle population is more than 20%. In developing countries more than 85% of water resources are used for agricultural purpose. So considering these facts India needs to use water judiciously especially in the agricultural sector. The state of Punjab with 1.5% area of the country, has been contributing 35 - 40% rice and 50 - 60% wheat to central pool since the last three decades. Intensive agriculture has adversely affected the state's water resources as it has increased the irrigation water requirement (Aggarwal et al., 2009). However, the surface water resource is not sufficient to meet the total irrigation needs. The percentage irrigated area from canals and tube wells in the state is 30 and 70% respectively. The number of tube well in the state has increased from 0.192 million in 1970 to 1.246 million in 2008 (Anonymous, 1970, 2008). Thus, the pressure on our water resources is continuously increasing. Therefore, to maximize production per unit of water resources, it is emphasized to utilize every drop of water available judiciously and carefully.

The efficiency of water utilization on the farmers' fields has been poor due to water losses in conveyance and during application at the field level. The situation arises due to lack of awareness among the farmers about the consequences of inefficient water application and lack of appropriate tools and instruments for uniform application of water. In the next decade, water is going to become a major limiting factor for sustained production. Appropriate instrumentation for water measurement, land levelling, water flow and soil moisture measurement and irrigation scheduling are needed in addition to a well-maintained conveyance network to have effective irrigation with a view to realizing high water use efficiencies. Not many tools and instruments are available for the farmers to undertake these tasks. In the absence of appropriate devices, farmers adopt obsolete and inefficient alternatives (Hamdy et al., 2003). Thus, under the present scenario, flow regulation on the farmers' fields through appropriate structural interventions are practically non-existent or in disuse. Lack of scientific water management causes loss of valuable water resources and the concept of application of a measured quantity of water in accordance with the crop water requirement is hardly practiced (Rajput and Patel, 2002). With the number of tubewells increasing in the state, it is important to know the accurate discharge of the tubewell so that required amount of water may be applied to the field. About 3.5 lps of discharge is required for 8 h to irrigate one hectare of land in case of non- paddy crop whereas for paddy about 4 l/sec discharge is required for same duration to irrigate same area. The method, which is frequently used at present, is the coordinate method, but this is not very

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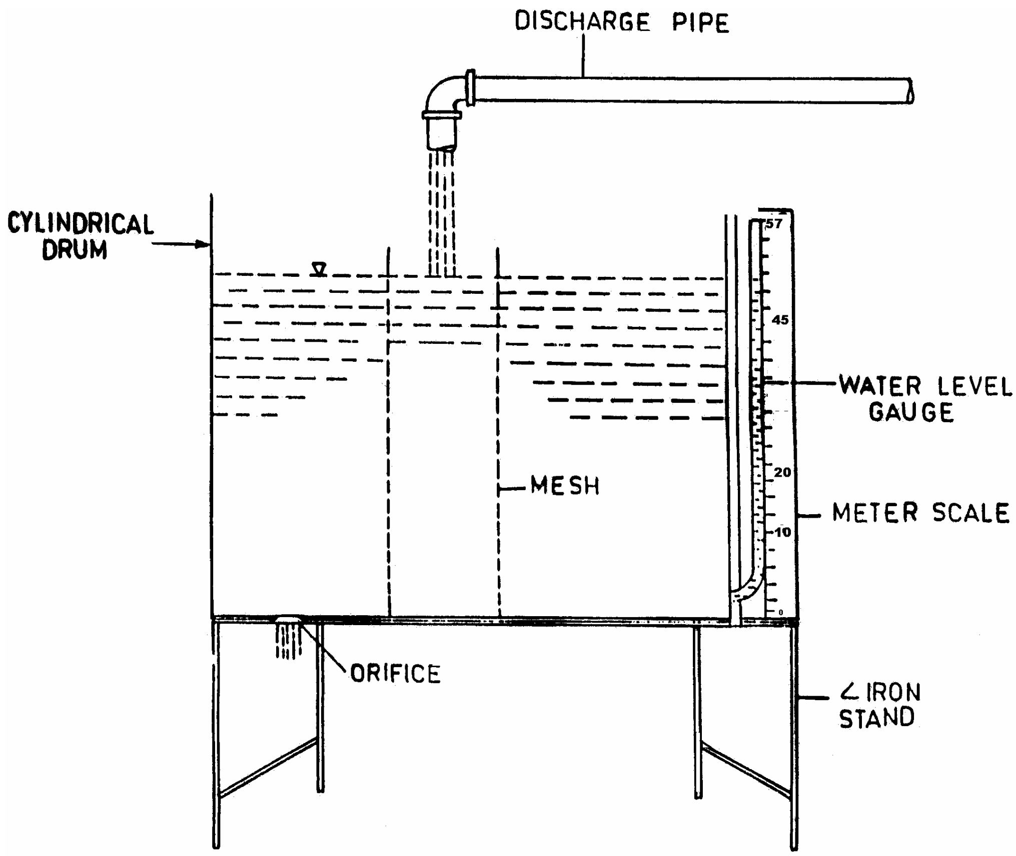

Figure 1. Schematic sketch of orifice bucket (not to scale).

accurate. Certain direct and indirect methods have only limited application in the fields as they need specific conditions to be met which may not be available. So, keeping in view the above difficulties and drawbacks efforts have been made to fabricate and calibrate an orifice bucket that can give accurate measurement and is easy to transport and operate. The water to be measured flows into the tank and discharges through the orifice provided at the bottom of the tank. The container fills with water to a level where the pressure head causes the outflow through the orifice to just equal the inflow from the pump based on Bernoulli's theorem. A suitable vertical scale is fastened to the outside so that the level of water in the container can be read accurately. The device is calibrated and the calibration curve shows the rate of discharge through an orifice of a given size for various values of pressure head.

EXPERIMENTATION

Construction of orifice bucket

It consists of a cylindrical drum of 74 cm diameter and 57 cm height fabricated from mild steel sheet in the Research Hall of Department of Soil and Water Engineering, PAU, Ludhiana. A large diameter hole was cut through the bottom of the drum and a leak proof arrangement was made on the backside of the bottom sheet for attachment different orifice plates (of 11.3, 10, 7.5 and 5 cm diameter). Near the base of the drum an elbow of 2.5 cm diameter was welded. A simple glass tube was connected to the elbow with the help of a rubber cork. A wooden scale (meter rod) was fastened to the outside of the drum to read the water level in the drum accurately. To reduce the turbulences produced by falling water from the delivery pipe, a 20 cm diameter perforated metallic screen cylinder was installed in the center of the drum and the water from the tubewell pipe was allowed to fall in the cylinder. Figure 1 shows the details of construction of an orifice bucket. Plate 1 and Plate 2 shows a fabricated orifice bucket.

Calibration of orifice bucket

The orifice bucket was calibrated on the Pump Testing Rig which is as per the BIS standards and is installed in the research hall of the college. Figure 2 shows the schematic sketch of the calibration circuit. The water was allowed to fall in the bucket and pass through the water-measuring tank fitted with a sharp edge 90° V-notch

Plate 1. Fabricated orifice bucket (Top view).

Plate 2. Fabricated orifice bucket (Side view).

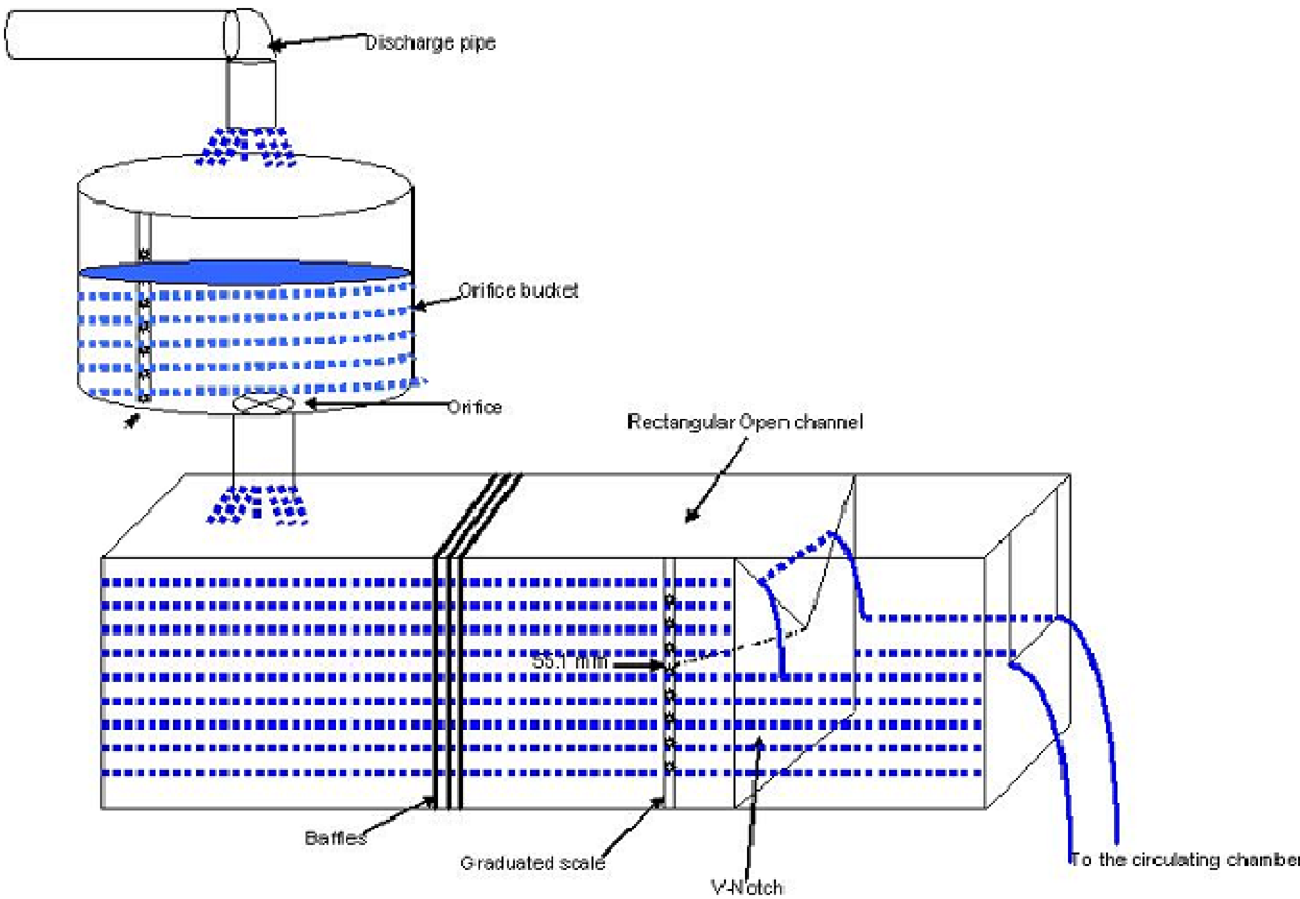

Figure 2. Schematic sketch of the calibration circuit.

made from brass sheet. The V-notch weir is a triangular channel section, used to measure small discharge values. The upper edge of the section is always above the water level, and so the channel is always triangular simplifying calculation of the cross-sectional area. V-notch weirs are preferred for low discharges as the head above the weir crest is more sensitive to changes in flow compared to rectangular weirs. After the steady state condition is achieved, the head on the upstream side of the V-notch was observed and the discharge through V-notch was computed by using the following formula (Henderson 1966).

$$Q = \frac{H^{2.48}}{21900}$$

Where Q = discharge, lps (litre per second)
H = head over the crest of the notch, mm

Modifications

During the calibration studies, it was observed that there were wide fluctuations in the water level of manometer so a second filter was also placed around the first filter. The flexible pipe was attached with the delivery pipe of the tubewell to put the discharge at the bottom of the bucket, to further reduce turbulences in water level.

Observations

The water level reading in the orifice bucket corresponding to a given discharge was noted from the manometer. The discharge through the delivery pipe was varied with the help of a gate valve. Using different settings of the gate valve calibration curve was prepared showing the discharge through orifice of a given size for various values of pressure head. Table 1 gives the value of head above orifice with respect to datum versus discharge through V-notch for orifices of 11.3 cm diameter. It was observed that it was possible to measure discharges ranging between 15 - 20 lps accurately by using 11.3 cm diameter orifice, so for discharges less than 15 lps replaceable orifices of 10, 7.5 and 5 cm diameter were fabricated and calibrated and are given in Table 2, 3 and 4 respectively. The calibration curve showing the rate of discharge through a given orifice for

Table 1. Observations of discharge with orifice diameter 11.3 cm.

Initial V-Notch reading corresponding to no discharge = 55.1 mm				
Sr. No.	**Head above orifice w.r.t. datum (mm)**	**V-Notch reading (mm)**	**Head above V-Notch (h-mm)**	**Discharge (l/s)**
1	87.5	176.5	121.4	6.74
2	110.0	187.0	131.9	8.27
3	123.0	191.0	135.9	8.91
4	177.0	205.0	149.9	11.16
5	195.0	207.8	152.7	11.90
6	250.0	215.7	160.6	13.48
7	265.0	218.0	162.9	13.97
8	295.0	220.5	165.4	14.51
9	337.5.0	225.5	170.4	15.62
10	365.0	228.4	173.3	16.28
11	390.0	230.5	175.4	16.78
12	405.0	232.8	177.7	17.33
13	417.5	233.0	177.9	17.38
14	435.0	235.0	179.9	17.87
15	458.0	238.0	182.9	18.50
16	490.0	239.7	184.6	19.05
17	515.0	242.0	186.9	19.64
18	545.0	243.7	188.6	20.09

Table 2. Observations of discharge with orifice diameter 10 cm.

Initial V-Notch reading = 55.1 mm				
Sr. No.	**Head above orifice w.r.t. datum (mm)**	**V-Notch reading (mm)**	**Head above V-Notch (h-mm)**	**Discharge (l/s)**
1	120	179.1	124.0	7.10
2	160	185.5	130.4	8.04
3	250	200.2	145.1	10.48
4	315	206.5	151.4	11.65
5	355	209.5	154.4	12.23
6	390	212.7	157.6	12.87
7	415	215.2	160.1	13.38
8	465	221.6	166.5	14.75
9	492	223.4	168.3	15.15
10	545	223.7	168.6	15.21

Table 3. Observations of discharge with orifice diameter 7.5 cm.

Initial V-Notch reading = 55.1 mm				
Sr. No.	**Head above orifice w.r.t. datum (mm)**	**V-Notch reading (mm)**	**Head above V-Notch (h-mm)**	**Discharge (l/s)**
1	117	159.5	104.4	4.63
2	150	166.3	111.2	5.42
3	200	172.0	116.9	6.13
4	280	178.8	123.7	7.06
5	355	184.3	129.2	7.86
6	395	186.8	131.7	8.24
7	460	190.3	135.2	8.80
8	505	193.5	138.4	9.32
9	545	195.0	139.9	9.58

Table 4. Observations of discharge with orifice diameter 5 cm.

Initial V-Notch reading = 55.1 mm				
Sr. No.	**Head above orifice w.r.t. datum (mm)**	**V-Notch reading (mm)**	**Head above V-Notch (h-mm)**	**Discharge (l/s)**
1	165	127.7	72.6	1.88
2	225	136.2	81.1	2.48
3	300	148.8	93.7	3.54
4	345	151.2	96.1	3.77
5	404	156.9	101.9	4.36
6	440	161.2	106.1	4.83
7	475	162.7	107.6	5.00
8	541	166.4	111.2	5.43

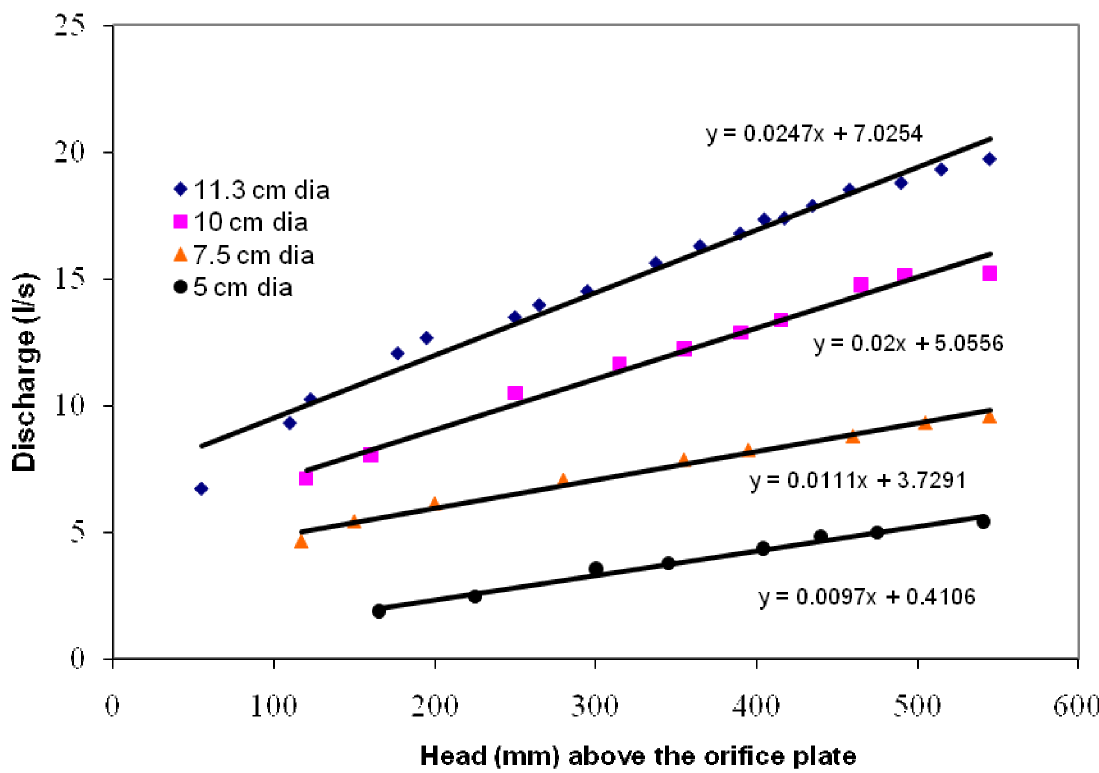

Figure 3. Rating curve for orifice bucket.

various values of pressure head is plotted in Figure 3. It was found that orifices of diameter 10cm, 7.5 cm and 5 cm accurately measured discharges ranging from 10 -15, 5 -10 and 1- 5 lps respectively.

Conclusions

An orifice bucket was designed, fabricated and calibrated and it was found that orifices of diameter 11.3, 10, 7.5 and 5 cm measured discharges ranging from 15 - 20, 10 - 15, 5 -10 and 1 - 5 lps respectively. The fabricated orifice bucket was found to be suitable for measuring discharges up to 20 lps at farmer's field. However for tubewell discharging greater than 20 lps larger diameter orifice bucket has to be fabricated.

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