International Conference on Mechanical, Industrial and Materials Engineering 2015 (ICMIME2015)
11-13 December, 2015, RUET, Rajshahi, Bangladesh.

Paper ID: FM-07

Comparative Study of Tara Dev and Hybrid Tara Pump with Respect to Water Level in Rajshahi

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Abstract

Hand pump technology is considered as being the best option for the water supply of rural communities in the developing countries. In this work, comparative study of Tara Dev and Hybrid Tara pump has been done with respect to ground water levels for different seasons in Rajshahi. Generally in Rajshahi the maximum and minimum depth of ground water levels are found in the month of March–May and August–October, respectively. The pumps have been experimented for static ground water level in between 56 ft to 16 ft. Different parameters such as water level, pump discharge, force required for pumping have been measured for both Tara Dev and Hybrid Tara pump and a comparison has been made between the two pumps. Maximum discharge by using Tara Dev pump was 35 lit/min and minimum discharge was 23 lit/min when uPVC pipe was used as buoyant rod. Under same situation, the maximum and minimum discharges in Hybrid Tara pump were 30 lit/min and 17 lit/min respectively. Hybrid Tara delivers water with lower values of applied force than that of Tara Dev pump. All of the users felt much interest for Hybrid Tara pump instead of Tara Dev for their household water uses. Due to good user acceptance, easy lifting, easy serviceability, lower force required during pumping, simple mechanism and low cost, Hybrid Tara has been selected as better option for household water supply in rural area.

Keywords**:** Ground water level, Hybrid Tara pump, Rural area, Tara Dev pump

1. Introduction

In Bangladesh, ground water is the predominant source of water supply. Hand pump tube wells lift the ground water and supply it in rural areas. Millions of people (principally women and children) spend a major amount of their daily lives fetching water. In many cases, the water comes from unprotected sources such as surface water. Hand pump technology was developed to lift ground water which sometimes holds huge quantities of safe water. Hand pumps, which are close to communities and offer access to safer fresh water, were considered to be the solution to improve children's education and allow a better quality of life for women. Their simplicity and ease of use were regarded as particularly major advantages as it was reported that human power was the most reliable and readily available source of energy for water lifting in the developing world.

Now-a-days water supplying with hand pump tube wells are facing severe problems due to various reasons and the major reason is the lowering of water table. In addition to the many places in the world where water tables are naturally very deep, increasing demography and global warming also have major impacts on ground water levels [1].In this case Tara Dev and Hybrid Tara hand pumps are very important because these pumps are cost effective, their discharge is also high and are able to operate at very deep water level. These hand pumps are Lever Action Pumps. When the static ground water level lowers down to an approximate depth of 35 ft, the manually operated suction type pump ceases to function, leading to stoppage of water lifting for human use. To combat such critical situation an idea was developed for a model pump named Hybrid Tara imposing some modifications on existing Tara Dev pump, in the portions of pump head and buoyant rod. Both of the existing Tara Dev and Model Hybrid Tara are manually operated pumps. But the former have some operational difficulties and limitations. In order to assess the superiority between Hybrid Tara and Tara Dev, these pumps were operated under different conditions throughout the year.

2. Fluctuation of monthly water levels in Rajshahi

Now-a-days groundwater crisis of Rajshahi area is highlighted. Water plays an important role in development of agricultural facilities in all parts of the world. Ground water condition of an area is mainly depending on geology, hydrology, hydrologic parameter, soil properties, recharge and discharge, hydraulic characteristics of aquifer. An important component of water balance equation is ground water recharge. This report focuses mainly on the performances of the Tara Dev and Hybrid Tara pump with ground water fluctuation and the trend of ground water level fluctuation in Rajshahi as well as to select the best performing pump. The vertical change in storage is not same throughout the year due to rainfall and infiltration for characteristics of soil in study area. The monthly fluctuation of ground water level at two different sites in Rajshahi district for five years is shown in Figs. 1 and 2. The maximum and minimum depth of water table are found in month of March–May and August–October respectively. Monthly variation of rainfall follows the usual pattern of monsoon with heavy rains from June to September [2].Global ground water storage is roughly equal to the total amount of fresh water stored in the snow and ice pack, including the north and south poles. This makes it an important resource which can act as a natural storage that can buffer against shortages of surface water, as in during times of drought. Ground water makes up about 20% of the world's fresh water supply, which is about 0.61% of the entire world's water, including oceans and permanent ice [3]. The increase of ground water can be achieved by infiltration of rainfall, recharge by seepage, surface flow etc. In order to maintain ground water supplies indefinitely the hydrological equilibrium must exist between all water entering and leaving the basin. The management of ground water is essential to obtain desired economic benefits. Maximum economic and beneficial use can be obtained by coordinating ground water and surface water resource. The proper management of ground water resources requires an adequate knowledge of extent of the storage, the rate of discharge, the rate of recharge to ground water body as well as the use of economical means of extraction [4].

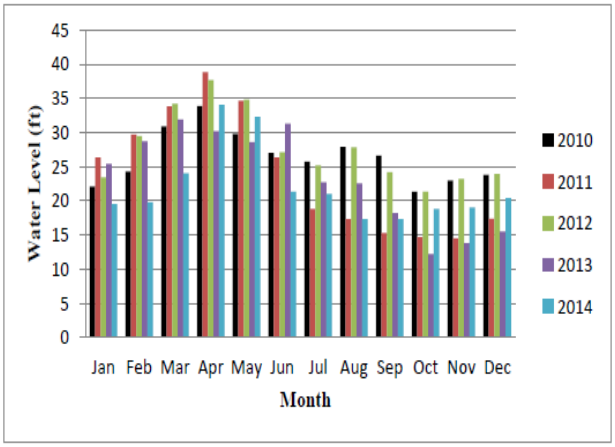

Fig.1. Fluctuation of ground water level in Kathalbaria mouza, Puthia, Rajshahi

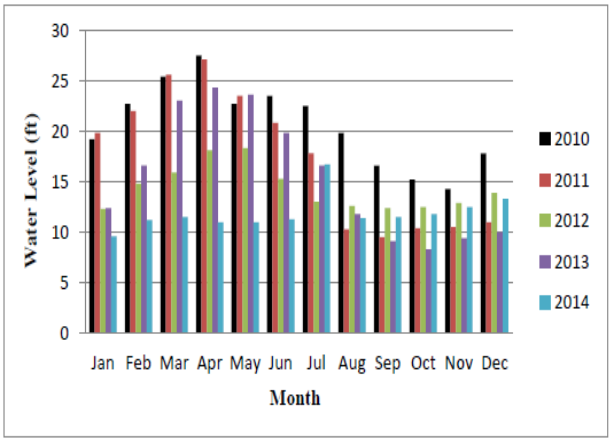

Fig.2. Fluctuation of ground water level in Bajubagha mouza , Bagha, Rajshahi

3. Differences between Tara Dev and Hybrid Tara Pump

Tara hand pump is a low-lift, direct action hand pump developed in Bangladesh using concepts that are now proving to be suitable for community water supply applications in other developing countries. Considering the problem encountered in rural water supply a technical committee comprising experts from different organizations started their work on Research and Development activities before 1982. Because of water table depletion, hand pump other than suction plunger hand pump was very essential to be introduced in Bangladesh. After a series of discussions, workshop and field verification, Tara hand pump technology for low water table area has been developed in Bangladesh in the year of 1984.Considering the importance and the magnitude of the Research & Development (R&D) activities, it was felt necessary to establish a separate setup of manpower to be engaged in Research & Development activities. Accordingly, the Research and Development Division of Department of Public Health Engineering (DPHE), was created in 1989 under GOB-Unicef project. The design of the pump has been developing since the first prototypes were produced in July1982, and at each stage the tara has been subjected to comprehensive testing both in the laboratory and in field trials [5]. Tara technology having lever action pump is termed as Tara Dev. Both Tara Dev and Hybrid Tara are lever action pumps. They operate on the same principles but they have some structural differences.Fig.3 shows the main components of Tara Dev pump.

In some cases, facing acute lowering of water level Tara Dev pump is not suitable. At this condition a new pump named Model Hybrid Tara has been developed by imposing some modification in the areas of pump head and buoyant rod .The pump head in Tara Dev is made of mild steel and in Hybrid Tara it is made of cast iron. Both Tara Dev and Hybrid Tara pumps were taken under experiment with two different sets of buoyant rod namely uPVC (Unplasticised Polyvinyl Chloride) pipe and PVC (Polyvinyl chloride) pipe. All other accessories for both of the sample pumps are same in design and operation.

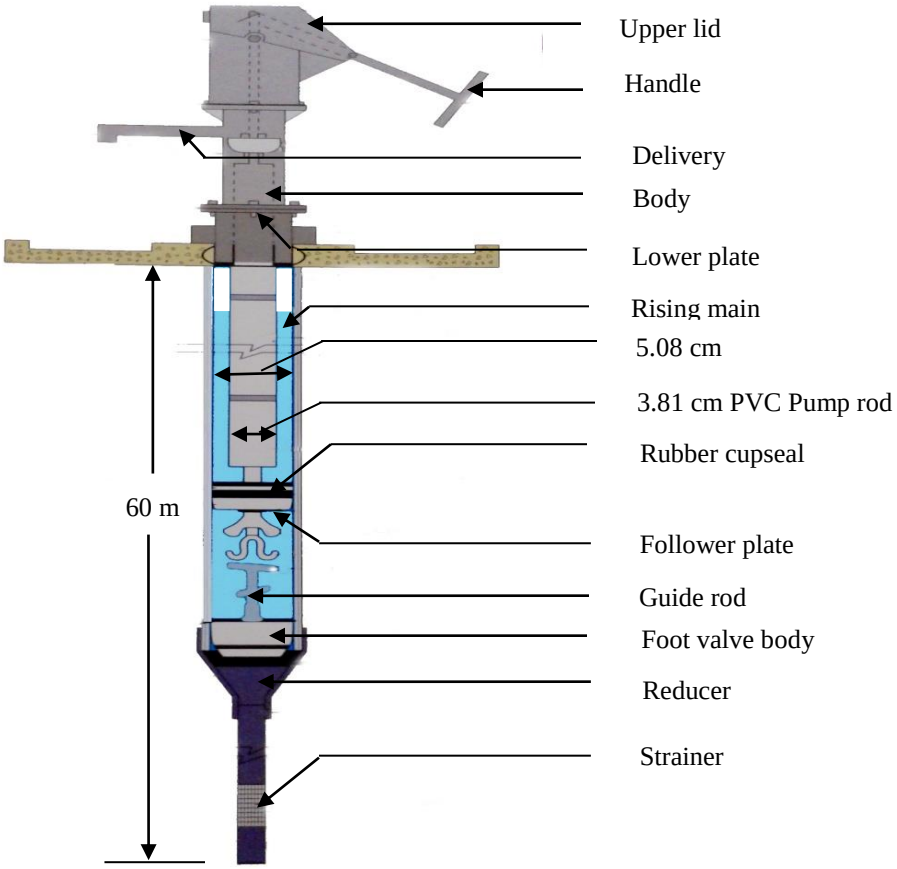

Fig.3. Main components of Tara Dev pump

Table 1. Distinctive features of Tara Dev and Hybrid Tara Pump

Components	Existing Tara Dev	Model Hybrid Tara
Pump head material	Mild Steel	Cast Iron
Weight of pump head	26.50 kg	24 kg
Stroke length	22 cm	20 cm
Dimension of the cylindrical body	ID = 8 cm , OD = 8.60 cm Height = 45 cm	ID = 8.80 cm ,OD = 10.18 cm Height = 50 cm
Buoyant rod	(i) PVC pipe with weight 5.58 gm/cm, ID = 3.81 cm, OD = 4 cm, Total length = 19.81 m (ii) uPVC pipe with weight 4.10 gm/cm, ID = 1.91 cm, OD = 2.54 cm, Total length = 19.81 m	(i) PVC pipe with weight 5.58 gm/cm, ID = 3.81 cm, OD = 4 cm, Total length = 19.81 m (ii) uPVC pipe with weight 4.10 gm/cm, ID = 1.91 cm, OD = 2.54 cm, Total length = 19.81 m

4. Experimentation on Tara Dev and Hybrid Tara Pump

In this experiment, the fluctuation of ground water level was recorded for the place located inside the RUET campus near Talaimari in Rajshahi. During the experiment different parameters such as ground water level, pump speed, pump discharge, force required for pumping were measured. The depth of static ground water level was measured directly by a graduated tape. During the operation of the pump, number of strokes were counted for a fixed time period. The time was recorded by a stopwatch. The pump speed (stroke/min) was determined by dividing the number of strokes by the time spent. A graduated bucket was filled for a known period of time. Pump discharge in (litre/min) was calculated by dividing the amount of water by the measured time. Force required for pumping was measured by using force meter in Newton. The parameters were determined for the two pumps with varying water level in different seasons for different operators and a comparison between the performances of the pumps were made. The tendency of a fluid to uplift a submerged body because of the upward thrust of the fluid is known buoyancy. In this study buoyancy force was calculated using the following equations:

$$\text{Buoyant force, } F_B = V\gamma \quad (1)$$

$$\text{Volume of water displaced, } V = \pi r^2 L_s \quad (2)$$

Where, r = radius of the buoyant rod which was 0.009525 m for uPVC pipe and 0.01905 m for PVC pipe.
L = length submerged in water which was 9.144 m when ground water level was 10.67 m
Unit gravity force of water, γ = 9806 N/m^3
Theoretical value of effort was found from lever principle using the following equation:

$$F_1 = (F_2 l_2) / l_1 \quad (3)$$

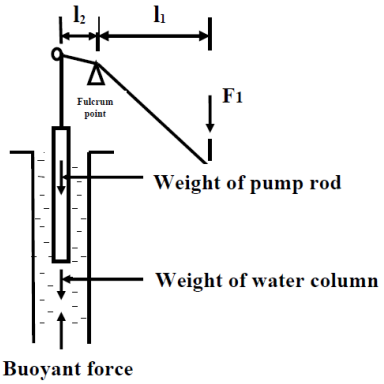

Fig.4. Lever principle in hand pump

Where, F_1= effort in Newton, Pumping load, F_2 = (Weight of water column + Weight of pump rod) in Newton
l_1= horizontal distance from effort to fulcrum in meter, l_2= horizontal distance from load to fulcrum in meter
When ground water level was 10.67 m (using uPVC pipe), the value of F_1 was found 91N from force meter and that was found 81.5 N from equation (3) .

Fig.5. Operation of Tara Dev by a 29 years old male operator

Fig.6. Operation of Hybrid Tara by a 29 years old male operator

Figs.5 and 6 show the operation of the two pumps (Tara Dev and Hybrid Tara) by a male operator when ground water level was 47 ft. In this case the discharge obtained by Tara Dev and Hybrid Tara pumps were 35 lit/min and 30 lit/min respectively when uPVC pipe was used as buoyant rod and the force required for pumping was 100 Newton for Tara Dev pump and 92 Newton for Hybrid Tara pump. For the same operator, using PVC pipe, the discharge was 32 lit/min for Tara Dev pump and 28 lit/min for Hybrid Tara pump and the pumping forces were 110 Newton and 95 Newton respectively.

5. Results and discussion

Both of the sample pumps were experimented for static ground water level in between 15 ft to 56 ft. The readings of water levels were taken for two times in each month. In Rajshahi the maximum and minimum depth of ground water levels are found in the month of March–May and August–October, respectively.

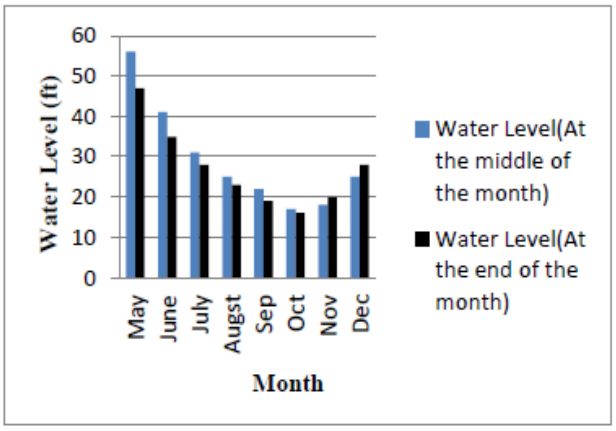

Fig.7. Fluctuation of ground water level at the selected site

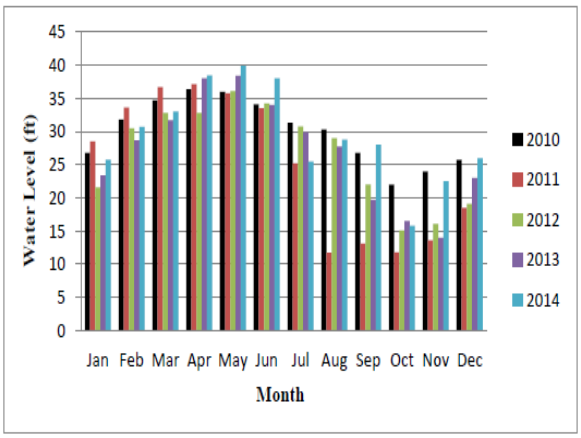

Fig.8. Fluctuation of ground water level for five years at Shantoshpur, Paba, near the site

From Figs.7 and 8 similar results are found. For both places, the maximum value of ground water level fluctuation was recorded in the month of May and the minimum value was found in October. In this study, better performance was obtained by the Model Hybrid Tara pump while uPVC pipe was used as buoyant rod. The performance obtained from experimental study on the both existing Tara Dev pump and Model Hybrid Tara pump are shown in Figs.9-12. It was found by the experimental investigation that the Hybrid Tara shows better result with respect to comfort level and operating force but discharge is slightly less than Tara Dev pump. The results are also greatly affected by the static ground water level, type of operator and operation mode of the respective people for both pumps. The Model Hybrid Tara pump gives discharges with lower values of applied force than Tara Dev pump due to less weight and diameter of the buoyant rod, and simplicity in mechanism.

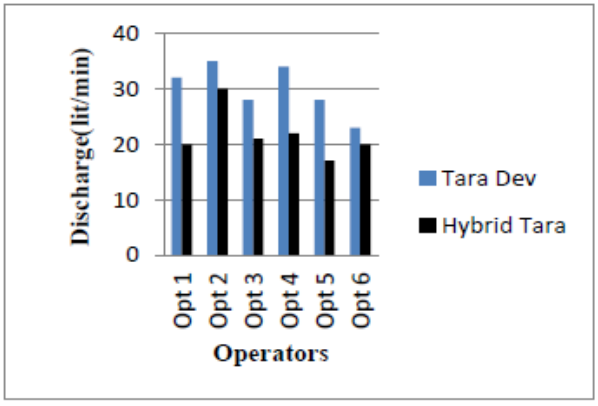

Fig.9. Water supply rate by Tara Dev and Hybrid Tara Pumps with respect to pump operators

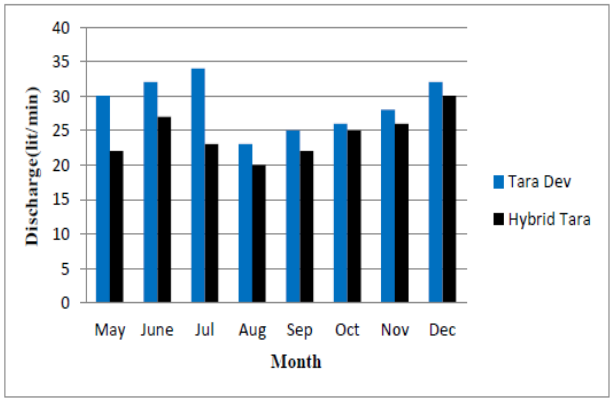

Fig.10. Discharge obtained for the same operator over the whole time period (May-December)

Fig.9 shows the difference in discharge between Tara Dev and Hybrid Tara pump for different operators. On the other hand, Fig.10 shows the discharge obtained for the same operator. In both cases, higher discharge is found from Tara Dev pump than that of Hybrid Tara.Figs.11 and 12 show the force versus operator curve using uPVC pipe and PVC pipe respectively.

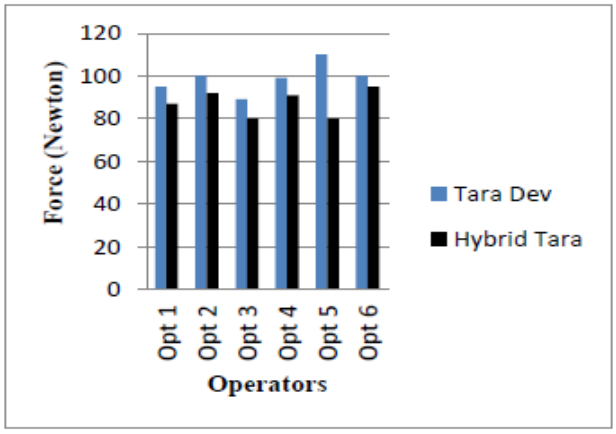

Fig.11. Force Vs Operator curve using uPVC pipe

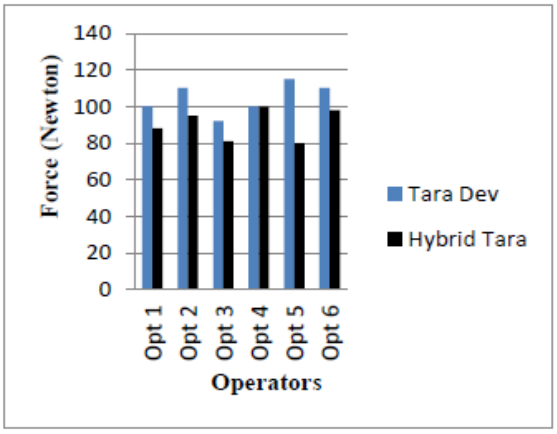

Fig.12. Force Vs Operator curve using PVC pipe

The value of applied force is found directly from the force meter. But the theoretical value of applied force is 10.4% less than the practical value.

All of the users have been feeling much interest for Hybrid Tara pump instead of Tara Dev for their household water. Thus Hybrid Tara pump can be selected as better performing pump because of it's-

- Good user acceptance
- Easy lifting
- Easy serviceability, minimum downtime
- Simplicity in mechanism and
- Low cost

6. Conclusions

- The comparative study of the two pumps reveals that higher discharge is found from Tara Dev pump.
- Hybrid Tara delivers water with lower values of applied force than Tara Dev pump.
- Because of easy lifting and simplicity in mechanism, Hybrid Tara has been accepted as better performing pump by all the operators.

7. References

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