*e-planet* **18** (2): 181-184 (December 2020)

# Estimation of cost of pumping from a shallow tubewell for agricultural usage

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Date of receipt: 10.08.2020 Date of acceptance: 10.12.2020

## ABSTRACT

The cost of pumping takes a major share under an irrigated agriculture condition, similarly for perennial aquacultural practices the importance of assured water cannot be ruled out. The procedure for determination of the cost of pumping is a cumbersome job. In this paper, the various steps involving the development of a shallow or deep tubewell and determination of unit cost of pumping under a sub-humid and sub-temporal condition of eastern India are discussed. Considering the electricity charge same as that of agricultural use, cost of pumping one cubic meter of tubewell water was estimated to be ₹ 1.93 or say ₹ 2.00.

**Key words:** Aquacultural practices, irrigated agriculture, sub-humid condition, tubewell water, unit cost

## INTRODUCTION

The importance of water is realized in agriculture and allied activities. Due to shortage of surface water resources, pressure is now to exploit ground water for fruitful usage. Due to shortcomings of rainfed agriculture where sustainable grain production may not be assured, importance is given on irrigation. Irrigated agriculture provides around 40% of global food production and covers about 20% of the cultivated land (Ray et al., 2018). It was estimated that irrigated agriculture is twice more productive and allow intensification and crop diversification in long run. Under global climate change scenario, it is estimated that we need to produce around 70% of more food grain globally by 2050 to maintain the basic minimum requirement (Lorenzo et al., 2018). Pumping huge amount of water either by adjacent river lift or from ground water involves a good amount of monetary outlay. Apart from direct agricultural water usage and domestic water demands, water demands from various sectors like livestock sector, poultry etc. too depend on a constant and perennial water supply (McDougall, 2015). Though aquaculture is not a consumer of water, still for its sustenance an assured water supply is also mandatory (Ray et al., 2006, 2008).

Electricity and diesel energy in one hand and solar and other forms of renewable energies on the other hand have put the end users at a cross juncture to take some critical decision. The importance of renewable forms of energy is advocated by various agencies; however, its huge initial infrastructure cost and limitation of technical knowhow could not bring this technology under farmers` friendly umbrella. The importance of electric and diesel operated pumps has been realized for agricultural and allied sectors and their number is also increasing steadily in the 21$^{st}$ century. About 18.5 million electric operated pump sets are available in India (GoI, 2012) and this number is gradually increasing.

In this paper an attempt has been made to discuss the various aspect of development of a deep tubewell and the procedure for evaluation of unit cost of pumping water from an aquifer using the tubewell.

## MATERIALS AND METHODS

Field experiments were conducted at the aquacultural experimental farm, Agricultural and

Food Engineering Dept., IIT, Kharagpur, West Bengal to assess the unit cost of pumping ground water for agricultural usage. The site selected for the field experiments represents a typical upland condition seen in eastern India. It is located at a latitude of 22° 19' N and longitude of 87° 19' E with an altitude of 48 m above the mean sea level. The site falls under sub-humid, sub-tropical region with an annual rainfall of 1400 mm, 80% of which is received during the rainy season that spreads over June to September. The rainfall pattern of this region is quite erratic.

**Development of a deep tubewell**

**Resistivity survey**

Before drilling a deep tubewell scientific resistivity survey was conducted at the experimental site to assess the potential aquifer at a particular depth. Resistivity survey was carried out with the Wenner`s Array arrangement up to 120 m depth to assure the availability of the potential aquifer. The variation of apparent resistivity measured at various depths was noted and plotted in a graph (Fig. 1).

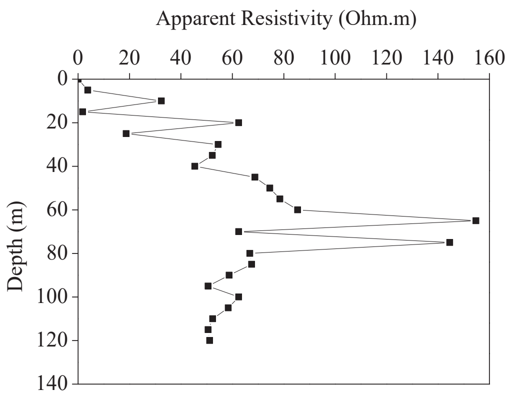


**Fig. 1.** Variation of apparent resistivity with depth

It may be noted from Fig. 1 that, with the increase in depth, the apparent resistivity value goes on increasing steadily upto 60 m depth. However, after 60 m depth there is a sharp decline in the resistance value showing the potential occurrence of groundwater but this depth did not last long predicting a less width band of aquifer. After 100-110 m there is a gradual decrease in resistance. Hence, the potential aquifer thickness is likely to be large.

**Drilling activities**

A schematic diagram of the mini deep tubewell is shown in Fig. 2.

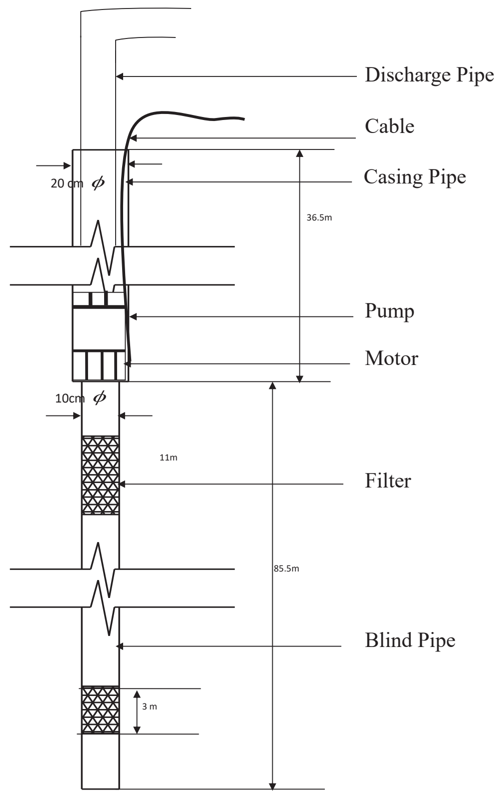


**Fig. 2.** Schematic diagram of the mini deep tubewell fitted with pump assembly

Direct rotary drilling was done with the help of a 10 hp modified engine setup. Two potential aquifers were located at 40 m and 110 m below the soil surface. Tubewell screens were provided at these depths to harness the maximum possible groundwater. Blank pipes of 100 mm diameter were lowered in the lower aquiclude portion to act as the tubewell pipe. Above this, casing pipes of 200 mm diameter were lowered. Suitable pea size gravel packing was done around the well pipe up to the top screen. The well was developed by using a high pressure compressor. After the well development, a 5 hp submersible pump was lowered to pump the ground water. The deep tubewell yields an average discharge of about 4 litres per second. While selecting a particular size or specification of a submersible pump, the aquifer discharge curve and delivery head of water to be pumped are mostly matched and based on the intersection of these two curves the pump capacity is decided (Machiwal et al., 2011). Under the present study, the intersection point was 4.73 hp, hence the next higher capacity pump, *i.e.*, 5 hp was taken.

**Initial investment**

The initial investment includes the cost of the following components, *viz.*, drilling pipe cost, cost of labour work per unit depth based on the depth of drilling, costs of pump along with motor, casing, filter, necessary fittings and accessories. The cost of development of the tubewell using a compressor is also included in the initial investment.

## RESULTS AND DISCUSSION

The details cost of development of a deep tubewell is presented in Table 1. The various cost components, *viz.*, resistivity survey, cost per unit depth of drilling, cost per unit length of pipe, cost of filter, cost of pea gravel, cost of pump assembly, cost of well development and other miscellaneous cost also included. The various items cost was taken from the West Bengal Public Works Department, 2006 (GoWB, 2006).

**Table 1.** Cost of development of a deep tubewell

| Sl. | Particulars/ items | Unit | Construction/ development made | Rate per unit (₹ per unit) | Cost (₹) |
|---|---|---|---|---|---|
| 1. | Resistivity survey | Lumpsum | One unit | 6,000 | 6,000 |
| 2. | Labour cost for tubewell drilling | Per meter | 150 | 120 | 18,000 |
| 3. | Pipe | -do- | 130 | 120 | 15,600 |
| 4. | Filter | -do- | 120 | 15 | 1,800 |
| 5. | Pump assembly | Lumpsum | 1 | 7,500 | 7,500 |
| 6. | Cable and electrical units | -do- | 50 | 15 | 750 |
| 7. | Pea gravel | -do- | 1,000 | - | 1,000 |
| 8. | Development of tubewell | -do- | One unit | 8,000 | 8,000 |
| 9. | Miscellaneous work | Lumpsum | 2,000 | - | 2,000 |
| | Total | | | | 60,650 |

The cost of development installation of a deep tubewell along with accessories amounts to ₹ 60,650/-. Considering 10 years of working life of the system, 10% annual interest on the investment and 1,000 hours of yearly operation, the hourly fixed cost comes to ₹12.13 ≈ ₹ 12.00 (say). The electricity cost for agriculture is subsidized and in it was ₹ 2.25 only per unit. The pump is of 5 kW capacity and therefore, consumes 5 units of electricity per hour for which the charge is ₹11.25. Annual maintenance cost was taken as 7.5% of the initial investment. Therefore, annual maintenance cost comes to ₹ 4,548. For 1,000 hours of annual operation, hourly maintenance cost is ₹ 4.55. Adding all these costs, hourly cost comes to ₹ 27.80. For a discharge of 14.4 $m^3$ (4.0 liter per second), cost of production of unit volume (one $m^3$) of water is obtained as ₹ 1.93 ≈ ₹ 2.00 (say). The unit cost of tubewell water was calculated and is presented in Table 2.

However, for pumping from river or other open water sources, the cost of development of tubewell need not be considered. The costs of pump and engine or motor along with necessary pipelines need to be included in the fixed cost. Remaining calculation procedure will be same as mentioned in Table 2.

**Table 2.** Unit cost of tubewell water

| Item | Interest (10%) | Amount (₹) |
|---|---|---|
| **Fixed cost** | | |
| i. Cost of tubewell and other accessories app expected life (10 year) | 6,065 | Fixed cost 60,650 Lumpsum<br>Depreciation (10%) 6,065 |
| ii. Hourly fixed cost per 1000 hour of yearly operation | | 12.13 |
| **Running/ Operational cost** | | |
| i. Electricity cost<br>5 KW h ₹ 2.25 per unit (agricultural usage) | | 11.25 |
| ii. (a) Maintenance cost | 7.50% | 4549 |
| (b) Hourly maintenance cost | | 4.55 |
| iii. Hourly fixed cost | | |
| (a) Tubewell + other accessories | | 12.00 |
| (b) Electric cost | | 11.25 |
| (c) Maintenance cost | | 4.55 |
| (d) Total hourly cost | | 27.80 |
| Average discharge from deep tubewell (4 Lps) ≅ 14.4 $m^3 h^{-1}$ | | |
| Cost of production of one cubic meter of tubewell water | | ₹ ≅ 1.93 |

## CONCLUSION

Considering the various fixed and variable cost components for installation of a tubewell in an aquifer and pumping water from the same, it was estimated that for pumping 1,000 liter of water from a deep tubewell installed in a typical aquifer prevailing under Kharagpur situation, West Bengal, India using a submersible pump of 5 hp capacity the unit cost of pumping was ₹ 1.93 or say ₹ 2.00. The cost of electricity varies from state to state; however, government provides subsidized electricity for agricultural and allied sector usage in all states.

## ACKNOWLEDGEMENT

The authors duly acknowledge the funds used made available from the Indian Council of Agricultural Research, New Delhi, for conducting the field research at Indian Institute of Technology, Kharagpur, West Bengal, India.

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