WATER MANAGEMENT: THE ADAPTION OF SURFACE CENTRIFUGAL PUMP TO BOREHOLE UTILIZATION

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ABSTRACT

The importance of water cannot be overemphasized. Also the cost of accessing water cannot be relegated to the background. With the rise of several organized and unorganized estates, individual residence, farms and business premises, the need to source for water is imperative. Drilling of boreholes by end users is the quickest way to get water. Some of these wells could come out very productive or not productive. The economic investment into drilling should be greatly minimized by reducing the number of holes drilled and also by reducing the number of wells abandoned. Utilizing the productive ones for multiple end consumers and salvaging the not so productive wells can be done by adapting a surface pump to them. An experiment was carried out on a borehole at Kuje Area Council of the Federal Capital, Abuja that has a maximum depth of 30 meters to determine at what depth a 1hp surface pump can suck from it using three sets of pipes of internal diameters (ID) of 14mm, 22mm and 29mm and with a constant discharge head of 2.4 meters. The foot of the pipe was fitted with a Non-return-Valve instead of a spring loaded foot valve so as to reduce the suction work on the pump. The result shows that water can be pumped from a suction depth below 10meters. Also, the smaller the internal diameter, the lower the water flow (discharge). At about 29meters suction head, the 14mm ID pipe sucked with a flow of 8 litres per minute, the 22mm ID pipe sucked with a flow of 17 litres per minute while the 29mm ID pipe sucked with a flow of 22 litres per minute. All these flow rates conform with the pump minimum design flow rate of 6 litres per minute. Also, with the rate of power fluctuation in our part of the world, damage to submersible pumps has been rampant; hence maintenance of borehole will be easier done with the surface pump than the submersible pump. The use of automatic controls will assist in harvesting water efficiently.

Keywords: water, pump, pipe and diameter

1. INTRODUCTION

Why are you considering drilling boreholes – what are your objectives and expected benefits? For example, how much water do you need and what do you require it for – irrigation, sanitation, domestic supply, stock watering or other? These choices will affect the water quality and quantity required. If you need water for toilet flushing and sanitation, then a low-yielding borehole will be sufficient. If you require extensive, high quality water supplies for domestic use or crop irrigation, then a low-yielding borehole will not be of any use. Raising water for drainage and irrigation were amongst the foremost motives of humans for the development of devices that lift water. In the absence of these water lifters, several portions of the globe will not be suitable for comfort in area of agricultural, home and other use [1]. The general notion is that a borehole can only be evacuated using a submersible pump. Yes that can be true since science have proved that water can only be drawn from 10meters due to the atmospheric pressure exerted on water. When asked about why is it impossible to pump water from a very a deep well with a surface pump, Scott Wilber, an expert in pumps answered thus; "Water is pumped from a well by creating a partial vacuum above the water by the pump. The amount of vacuum, in inches of mercury, is equal to the weight of the column of water from the water table to the surface. Atmospheric pressure at sea level is 29.92 inches (approx. 76 cm) of mercury. This is equivalent to a column of water 406.7 inches or 33.9 feet (approximately. 10.3 m). Therefore, a total vacuum could only pump water from a depth of just under 34 feet or 10.3 meters. Actually, a total vacuum cannot be created over water. As the pressure is reduced, the boiling point of the water is lowered, producing a layer of water vapor between the water's surface and the pump. The water vapor reduces the ultimate vacuum and the maximum pumping depth, but only by about 0.7 inches (1.8cm) at 20°C [2]. From the above response, it is deduced that a "Total Vacuum" can't move water up from a depth not more than 10.30m. This accounts for the reason why boreholes are not fitted with surface pump owing to the notion that any depth beyond 10metres, suction may not occur. The drilling of boreholes have become so rampant within a small area and it is becoming a subject of discussion in the water industry. With the increase of property development and the reduction in social amenities especially water, hence the need for quick and portable water. The haphazard digging of boreholes in the country seems to be getting out of hand, with the official alarm raised by the Federal Government. Mrs. Sarah Reng

Ochekpe, (Former) Minister of Water Resources, during a courtesy visit on her by members of the Association of Water Well Drilling Rig Owners and Practitioners in Abuja pointed out the peril inherent in such habit. She said: “The construction of boreholes indiscriminately is capable of causing earth tremor. The need for proper and effective regulation of groundwater abstraction is now of utmost importance” [3].

Drilling for water is a risk, so you need to factor that in when paying for groundwater exploration – you want to avoid it becoming a time-consuming liability with continual repair or replacement of pumps, due to poor borehole construction, wrong pump installation or incorrect pumping [4]. Also the rate of abandonment of boreholes due to what is called low yield should not be encouraged. The cost incurred for the drilling can’t be recovered. The need to reduce the number of holes (Boreholes) dug in an area yet meeting the needs of the consumers is required. Also, maintenance cost, number of personnel needed for the maintenance of a borehole is high due to the fact that the whole apparatus will have to be removed and reinserted after rectification.

2. MATERIALS AND METHODS

2.1 Materials

The materials used for this work were bought and assembled. The measurement of parameters was done using locally available instruments and direct measurement.

Materials used are listed below.

1. A One horse power Pump (1Hp pump) was used for the experiment. The details are summarised in Plate V

2. Generator. The generator used is of Thermocool brand and it is the Hustle Model. It’s operating voltage is 230V, frequency is 50Hz; Power is 2.8KW; Ampere is 8.3A and it’s Single phase.

3. PVC plastic pipes were used. For experiment 1, 14mm internal diameter (ID) pipes were used. For experiment 2, 22mm ID pipes were used while for Experiment 3, 29mm ID pipes were used.

Other materials used are tabulated as shown in Table 1

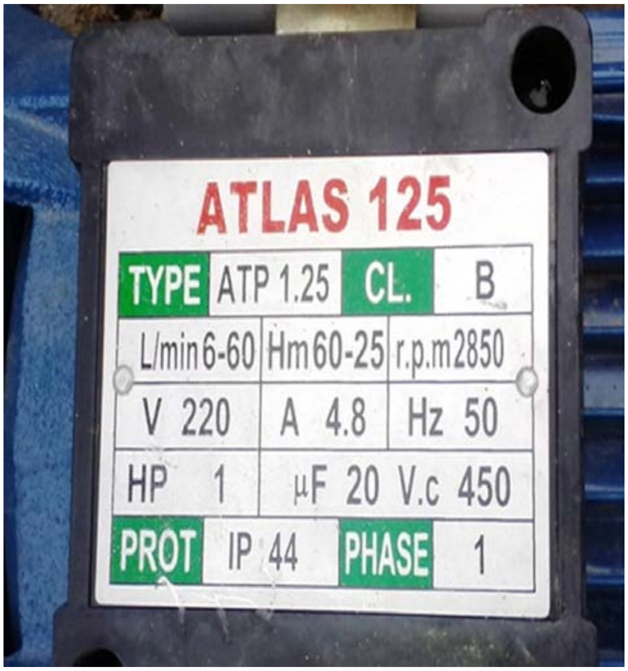

Plate I Pump Parameter
Source: Author's Pictures

Plate II Work Station Setup 2
Source: Author's Pictures

Table 1: List of some materials used

S/No	Description	Qty	S/No	Description	Qty
1	29mm Non Return valve	1	13	32X25mm bushing	2
2	32mm union	11	14	16mm Non Return Valve	1
3	32mm adaptor	16	15	16mm Union	1
4	32mm M/F socket	14	16	16mm adaptor	31
5	32mm Tee	1	17	16mm M/F socket	30
6	32mm ball valve	1	18	16mm elbow	1
7	32mm ball valve GI	3	19	16X25mm bush	1
8	32mm elbow	1	20	Stop watch	1
9	25mm Non Return Valve	1	21	Jotter	1
10	25mm adaptor	22	22	Water level indicator	1
11	25mm M/F socket	20	23	Calibrated bucket	1
12	25mm union	1	24	Plastic Basin (Bowl)	1

2.2 Methods

Pipes for the experiment are cut to sizes and fixed with their connecting ends. These are adaptors (Plate III), Male/Female (M/F) sockets (Plate III), union connectors (Plate IV) for the pump inlet and discharge. The 1hp pump was placed on the ground as shown in Plate VII. The water level indicator, which was graduated, was sent down. When the tip gets in contact with water in the borehole, it gave an alarm and the depth was noted. With this information, the Non-Return-valve (see Plate V) was attached to the first pipe with marine rope firmly tied on it. Other lengths of pipes were attached and gradually lowered till they get to the point below the static water level. The pipes were sent down by attaching the adaptor end to the screw end of the M/F socket (see Plate IV). At this point the short piece that had adaptor at one end and union connector at the other end (Plate VI) was screwed to the M/F socket. The threaded points were sealed with thread tape to make them air tight. This would prevent air intake. The discharge pipes were also assembled before the commencement of the experiment and support ropes were used to balance them to position. The pump was primed through the priming port while the discharge valve was in open position. As soon as the priming port was filled up, the discharge valve and the priming port valves were closed simultaneously. Then the generator was powered. Its Output voltage is 220volts (Plate I). As soon as the switch was turned on, the priming port valve was gradually opened to let out any air in the system (bleeding). When the air was bled off, the sound of the pump changed, indicating the commencement of pumping. Quickly, the priming port valve was closed and the discharge valve opened gradually until it was fully opened.

Water flowed out. The depth of the water was taken using the water level indicator; this was done to make sure that water did not go below the suction position (the non-return-valve position). As soon as the flow was steady, with the aid of the 5 liter bucket, the discharge was taken using a stopwatch. As soon as readings were taken, the pump was switched off and another pipe was added thereby, increasing the suction head. The suction head was increased till it got to 29meters. The above procedures were repeated for Experiments 1, 2 and 3.

Plate II: Picture of pipe connectors
Source: Authors Pictures

Plate III: Picture of two connected pipe
Source: Authors Pictures

Plate IV: Picture of Non-return-Valve
Source: Authors Pictures

Plate V: Picture of Union and Adaptor
Source: Authors Pictures

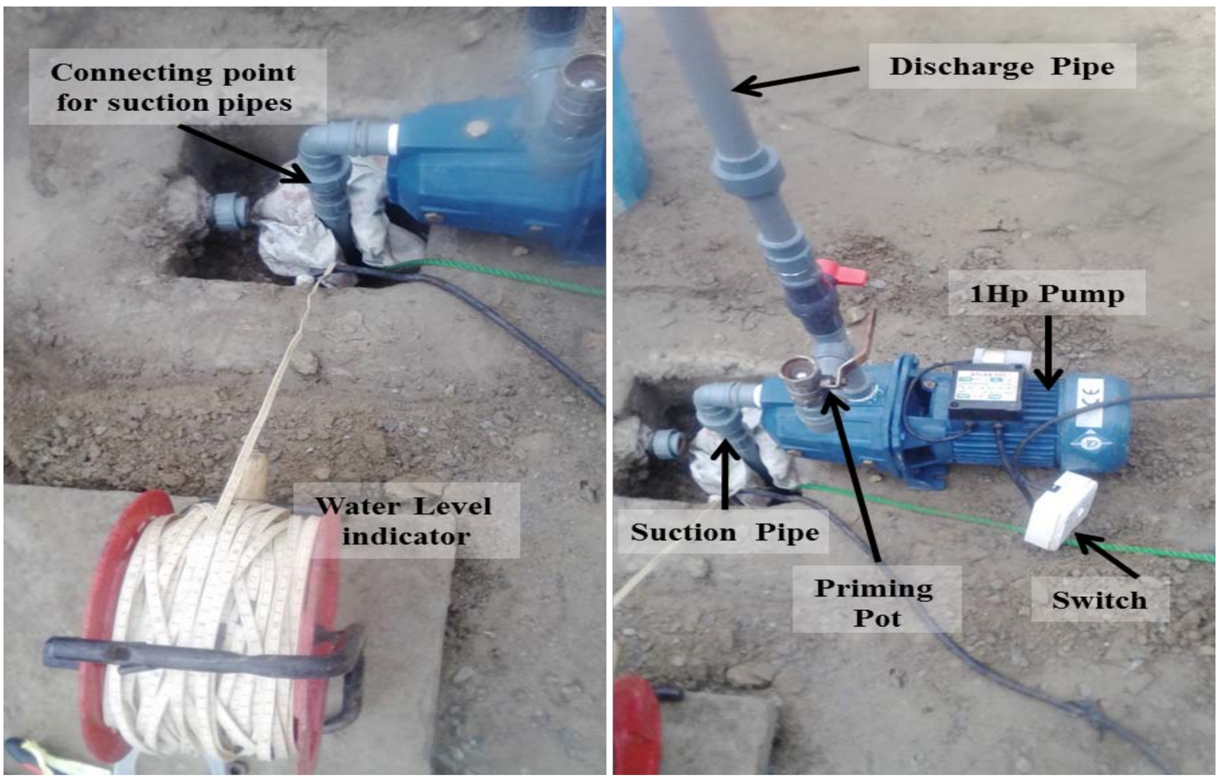

Plate VI: Work Station Setup 1
Source: Authors Pictures

3. RESULTS AND DISCUSSION

The results obtained from three experiments have been tabulated using excel software and are presented in Tables 2, 3 and 4

Table 2: Data generated for 14 mm ID pipe with discharged head of 2.4 m

Actual depth (m)	Water level (m)	Height of water above NRV (m)	Time to fill 5 litre cylinder (s)	Discharge Q (l/min)	Suction head (m)	Total head (m)	Discharge Q (m^3/s)
8	5.93	2.07	25.53	11.75	8.19	10.59	0.0001958
10	5.93	4.07	27.13	11.06	10.19	12.59	0.0001843
15	5.66	9.34	26.85	11.17	15.19	17.59	0.0001862
20	5.85	14.15	31.53	9.51	20.19	22.59	0.0001586
25	5.79	19.21	34.05	8.81	25.19	27.59	0.0001468
29	5.84	23.16	36.22	8.28	29.19	31.59	0.0001380

Table 3: Data generated for 22 mm ID pipe with discharge head of 2.4 m

Actual depth (m)	Water level (m)	Height of water above NRV (m)	Time to fill 5 litre cylinder (s)	Discharge Q (l/min)	Suction head (m)	Total head (m)	Discharge Q (m^3/s)
8	5.42	2.58	11.4	26.32	8.19	10.59	0.0004386
10	7.38	2.62	12.46	24.08	10.19	12.59	0.0004013
15	7.32	7.68	12.51	23.98	15.19	17.59	0.0003997
20	7.54	12.46	13.4	22.39	20.19	22.59	0.0003731
25	7.46	17.54	13.32	22.52	25.19	27.59	0.0003754
29	7.35	21.65	13.43	22.34	29.19	31.59	0.0003723

Table 4: Data generated for 29 mm ID pipe with discharged head of 2.4 m

Actual depth (m)	Water level (m)	Height of water above NRV (m)	Time to fill 5 litre cylinder (s)	Discharge Q (l/min)	Suction head (m)	Total head (m)	Discharge Q (m^3/s)
8	6.97	1.03	11.4	26.32	8.19	10.59	0.0004386
10	6.15	3.85	12.31	24.37	10.19	12.59	0.0004062
15	5.85	9.15	13.47	22.27	15.19	17.59	0.0003712
20	5.72	14.28	13.94	21.52	20.19	22.59	0.0003587
25	6.57	18.43	15.77	19.02	25.19	27.59	0.0003171
29	6.47	22.53	16.8	17.86	29.19	31.59	0.0002976

From Tables 2, 3 and 4, it is seen that the pump could suck water from a suction depth higher than 10m. From the layman's perspective this may not be possible. With priming, the pump was able to suck up to 29m from the 30m boreholes and a suction head of 29.19m. As the suction head increases the discharge reduces but looking at the suction depth of 29.19m, it is seen that the water discharge was still within the pump design. The water column above the suction position (non-return-valve) for the 29mm ID pipe is the lowest. This is due to the high rate of discharge. This height is inversely proportional to the pipe ID discharge behavior. As the ID increases, the discharge increases while as the ID increases the height of water above the non-return-valve reduces. From these tables, graphs are plotted so as to get a clearer perspective. The graphs are as shown in Figures 3.1, 3.2 and 3.3; the equations of the best fit line (trend line) have been used to generate values beyond the experimental readings. The non-return valve is one of the major factors responsible for the possibility of the pump to have suction at such debt. The usual foot valve is spring loaded, which work has to be done to overcome it has been eliminate with the use of the foot valve.

From the statement of problem, Table 3 can be used to solve the sinking of multiple boreholes. While a borehole is high yielding, two to three dwellings can insert the 29mm ID pipe inside the well and pump independently. Here the cost of sinking the well can then be distributed among the three consumers. This will save cost and the environment. Also, in cases where there are low yielding wells, Table 3 can be applied. We see that the pump could still deliver a flow of 8.28 liters in a minute. In places where the use of water do not require storage and also do not require high flow like in irrigation farm for some crops, this size of pipe with the corresponding pump can be used.

4. CONCLUSION

With the results obtained, the aim and objectives of this work has been achieved. In this work, the discharge head is held constant while the suction head is varied and pumping occurred in the borehole at a depth up to 30 meters. The use of different internal diameter pipe can be employed to suit whatever type of borehole available. For instance, if it's a low yielding borehole, a smaller diameter pipe will be fitted to the pump to reduce the suction rate and still achieve a good discharge value. Then if it's a high yielding well, a bigger ID pipe can be used. The components to install this pump are simple to assemble, therefore good for the less skilled. The use of cables to install a submersible pump is eliminated, this reduces trouble shooting items. Also, the surface pump ranging from 0.5hp (0.38KW) to 2hp (1.5KW) uses 1-phase power and it's a plug-and-play socket. Re starting of the pump was done without repeated priming, this is due to the effectiveness of the Non-return-valve. Generally, surface pumps are fitted with foot valves to serve as water retainer and to prevent debris from been sucked. This foot valves are spring loaded which may have contributed to the suction work of the pump. But with the introduction of the flap non-return-valve, the suction work on the pump is greatly reduced because water just flows into the pipe as soon as water is sucked because of the flap that is free. It is believed that the spring loading of the foot valve could serve as an extra suction work on the pump. Using the data obtained from the experiment, pipe selection and flow consideration can be observed.

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