DESIGN AND CONSTRUCTION OF AN AUTOMATIC WATER LEVEL INDICATOR AND CONTROL SYSTEM FOR OVERHEAD TANK

UGWU, S.J[1*]; JOSHUA, W[1]; AKINTAYO, T[1]

National Water Resources Institute, Mando, Kaduna, Nigeria
Corresponding Author: ebukush3@gmail.com

ABSTARCT
This study seeks to design and construct an easy configurable system that controls water level in an overhead tank or reservoir receiving flow from an aquifer without wastages. The water level sensors used for the design of the system comprise copper wires with high conductivity which play a major role in detecting, measuring, and monitoring of the water tank levels. The system design is based on simple electromechanical technology. The circuit was assembled on a Vero Board, three LED indicators – Red, Green, and Yellow which were connected to the three BC547 transistors T1, T2 and T3. Both the LEDs and the transistors were connected to 220? resistors R1, R2 and R3. Electrical energy was supplied to the system using a 12-volts power source. The red LED display indicates water at low level of fill, yellow LED at half-filled and green LED at full capacity and pumped water connected to the designed automatic water controller. The pump flow rate indicates an average time of 278.51 seconds to fill a twelve litres tank, and 277.68 seconds to fill same twelve litres tank without the use of the control system. Volume of pumped water against time was plotted and the slope of the graphs signify the actual flow rate achieved by the pump when coupled to the control system which is 0.09 L/S, and 0.100 L/S when not coupled to the control system. These results have significantly shown that the automatic water control system has no effect on the performance of the pump, but rather, helps to prevent over use of the pump and regulates how the pump is being used. The study recommends the use of Radio Frequency (RF) technology in subsequent research to determine the interaction between the controller and the water level sensor in pumping operation.

KEYWORDS: *Control system, pump, circuit, discharge, water level*

INTRODUCTION

A water level indicator is an electronic system that makes use of sensors to detect water level in a storage tank at a given instance or time (Depanjan *et al.,* 2016). It might not be possible for the operator to keep an eye on the water filling process of an overhead tank during pumping. This demands for an immediate switch off of the indicator manually at minimum operated capacity of the storage facility (Ajinkya and Milind, 2017). In cases where these conditions are not met, may result to unnecessary wastage of water (Hedge, 2012).

Water scarcity is a major challenge that is faced by most developing countries in the world (Liu, et al., 2017).This in some cases is triggered by non-adherence of national water policies and management (WEF, 2017). Most people, who have access to portable water resources, show a poor habit in its utilization and management (Brooks, 2006). The barrier on wastage not only gives us more financial savings, it also helps the environment and water cycle which in turn ensures water circulation in future (Moyeed and Rajendra, 2014).

Automatic water level control system has the capacity to operate independently with no one manning its operation (Rodseth, O.J, 2019). The system eliminates or reduces the chances of wastages that may result due to overflow of pumped water from a source to an overhead tank when no control system is put in place (Moyeed and Rajendra, 2014). It is an economical system that requires maintenance with no complicated circuits and delicate mechanisms as compared to the conventional system. The system requires only a few components that are easily made available (Oyndrila *et al.,* 2016). The sensing component of the system has the ability of enhancing the efficiency of operation and the pump life span.

The operation of water level controller works upon the fact that water conducts electricity. So water can be used to open or close a circuit (Hasan *et al.,* 2016). *Research conducted by* Monisha *et al.,* (2016) emphases on the use of Automatic Water Management System (AWMS) that can be implemented in places where wastage of water exists. The research involved the use of microcontroller, water pump, display and an assembly language program. The sensor has two main parts, detection system and monitoring system. The water level indicator monitors the filling of overhead tank and displays the water level on the screen. In a similar way, *research conducted by* Chu, *et al*., (2019), made emphases on water and energy as the two main pivotal reason of concern in today's world and with the rise in population the demand for both energy and water is increasing day by day (Chu, et al., 2019). They focused on ways to minimize the wastages associated to these essential resources, water and energy, which they achieved through the design and construction of an automated water pump powered by cheap electronic devices like Radio Frequency (RF) module, relay, Photovoltaic (PV) cell etc. The pump works on renewable power source that is, solar energy and includes automated water level indicator which indicates the water level at various stages of operation, when the tank is empty, mid-way and full (Wadekar, et al., 2016). This study seeks to design and construct an easy configurable system that controls water level in an overhead tank receiving flow from a groundwater source without wastages.

2.0 MATERIAL AND METHOD

2.1 Material

The materials used in the design and construction are: Water Level Sensor, BC547 Transistor, Resistors (220, 155, 1K, 10k Ohms), Light Emitting Diode (LED), Integrated Circuit (IC) 555 Timer, 1N4007 Diode, Single Pole Double Throw (SPDT) Relay Switch, Vero board, Step Down Transformer, Voltage Regulator IC7805, 7812, 1000 Micro Farad Capacitor, Rectifier, Centrifugal Submersible Pump (220volts), Electrical Panel Box and Water Tank.

2.2 Water Level Sensors

The water level sensors used for the design of the system are copper wires with high conductivity which play a major role in detecting, measuring, and monitoring of the water levels. The following technical considerations were adopted;

a) The positioning of the level sensor;
b) The type or kind of level sensorrequired;
c) The method of contact with the water;

d) Water level measurement by direct or indirect mean; and

e) Price

2.3 The System Design

The system design is based on simple electromechanical technology. Figure 1 shows the circuit design of the automatic water level indicator and control system for this study.

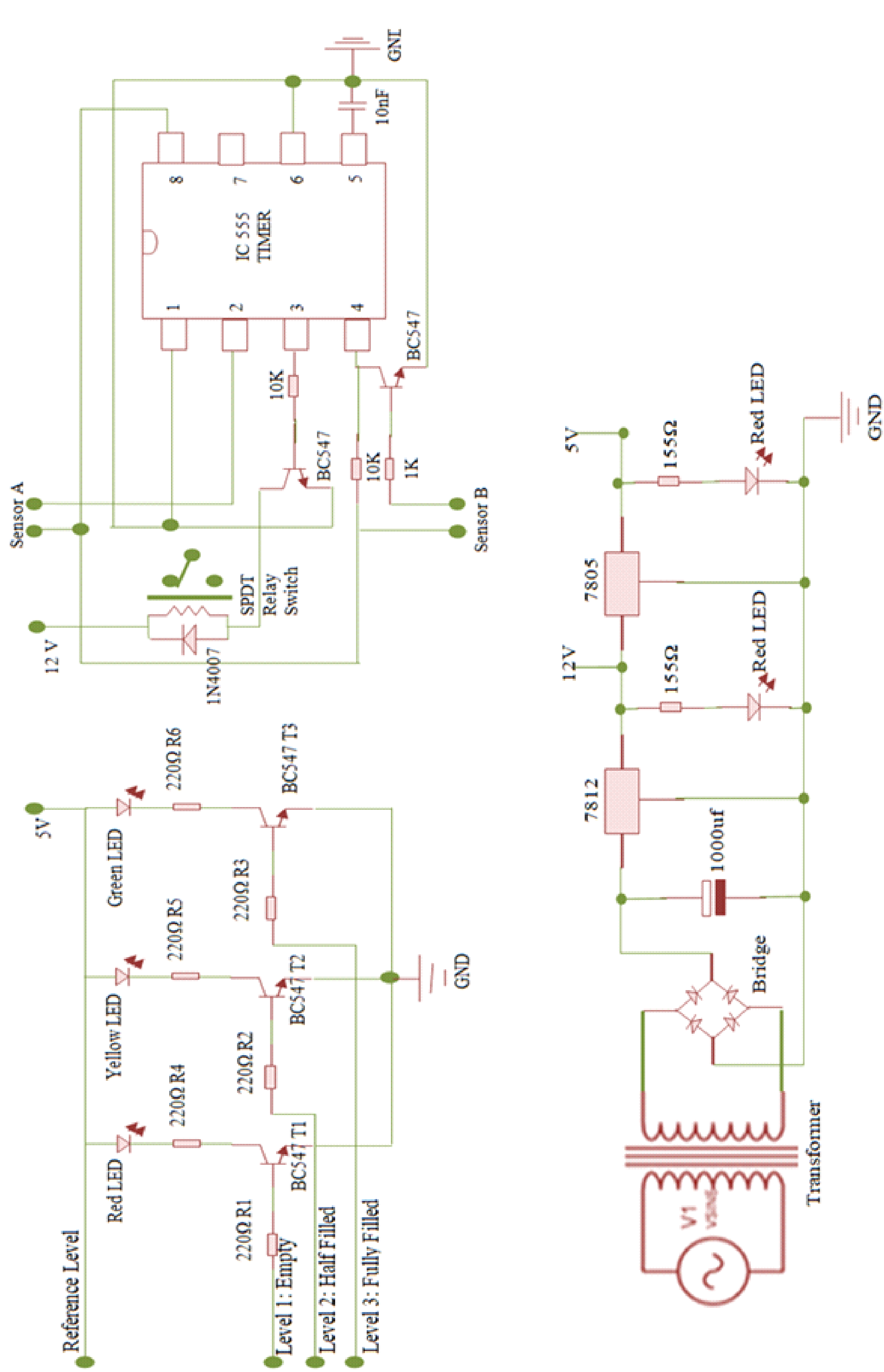

Figure 1: Circuit Design of the Automatic Water Level Indicator and Control System

The resistance of the regulator used in the design varies with load resulting in a constant output voltage. The power supply circuit has two voltage regulators, the first (IC7812) supplies 12Volts to the relay switch, the second (IC7809) decreases 12Volts to 9Volts used to supply to the indicator circuit. The full wave rectifier consists of four 1N4007 diodes and 1000µF capacitors which were used to convert the AC supply of the wall outlet to DC supply which will run the majority of the circuit elements. The circuit contains three (3) LEDs and three (3) resistors all connected to a panel electrical box. When the circuit is closed and the centrifugal pump is put in use, the LED indicators indicate when the water level in the tank is empty, half-filled and fully filled with a colouration of red, yellow and green respectively.

2.4 Construction Procedure

2.4.1 Water Level Indicator

The circuit is assembled on a Vero Board, three LED indicators – Red, Green, and Yellow were connected to the collector of the three BC547 transistors T1, T2 and T3. Both the LEDs and the transistors were connected to 220? resistors R1, R2 and R3. Short length single threaded copper wires are used as sensing probes A, B, C and D connected to the base of the transistor. A power supply of 5volts is supplied to the circuit from the dual power supply unit.

Automatic Pump Control System

The circuit is also assembled on the same Vero board with the water level indicator. Here the collector of the BC547 transistor K1 is connected to pin 4 of the 555timer IC, then 10K resistor is connected from the SPDT relay coil to the collector of transistor K1. Transistor k1 emitter is connected to transistor K2 emitter, then to pin 1, pin 5, and pin 6 of the 555 timer IC. 1 kilo ohms resistor is connected to the base of transistor k1 while 10 kilo ohms resistor is connected from the base of transistor K2 to pin 3 of the IC. The collector of transistor K2 is connected to pin 2 of the relay coil and 1N4007 diode is connected to the relay switch. The motor of the centrifugal submersible pump is connected to the normally closed terminal of the relay switch allowing it to work till the common pole is shifted to normally open terminal and a 12volts power is supplied to the relay switch is from the dual power supply unit. The entire assemble of the system is presented as a flow chart in Figure 2

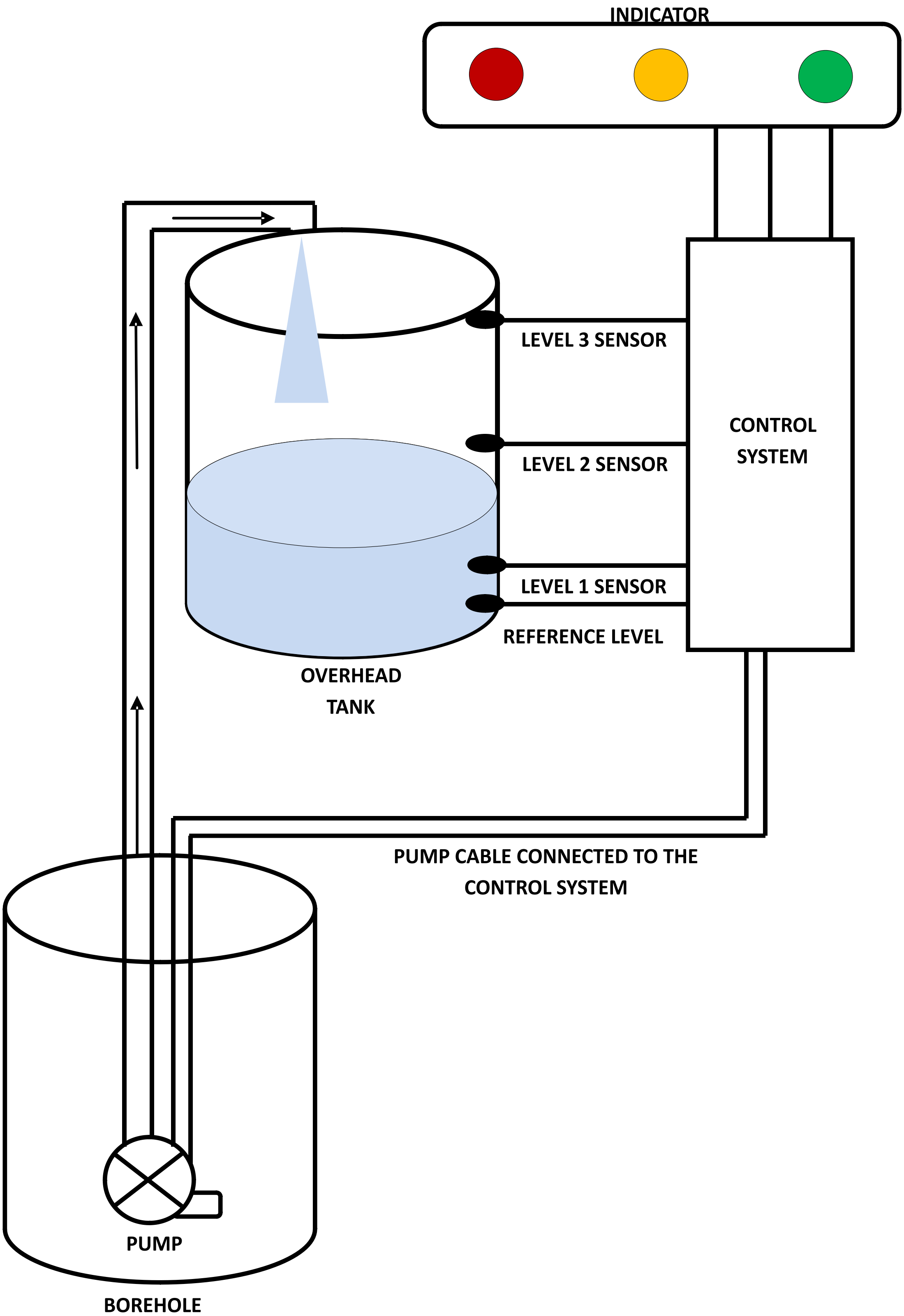

Figure 2: Flow chart of the Automatic Water Level Indicator and Control System

2.5 System Test-Run

To ascertain the performance of the automatic water level indicator and control system, the system was run five times daily at 20 minutes interval for five days. A twelve (12) litres water tank was used as the storage container and the sensors B, C and D which represent the low level, half-filled and filled level were placed at the position of two (2) litres, six (6) litres and twelve (12) litres respectively in the water tank. The time it takes for water to reach various sensors were recorded accordingly. Also, the pump was run without the automatic water control system for another five days, five times daily and at 20 minutes interval. The time it takes for water to reach the specified levels were recorded. With the daily average time, discharge rates were calculated and a graph of volume against time was plotted with and without the use of Automatic Water Control System. From the slope of the graph, the actual flow rate was determined.

3.0 RESULTS AND DISCUSSION

The measurement of the flow rates at different capacities of the tanks when sensor was used and when not in used are presented in Tables 1 and 2

Table 1: Volumetric rate at different sensing time when pump is in operation with the sensors

DAY ONE (Time of sensor indicator at filled level in seconds)						
	1st Reading (S)	2nd Reading (S)	3rd Reading (S)	4th Reading (S)	5th Reading (S)	Average Time (S)
Sensor A (2litres)	44.90	44.54	46.61	44.71	46.45	46.44
Sensor B (6litres)	86.77	87.76	90.00	86.73	89.26	88.10
Sensor C (12 litres)	144.85	146.84	152.33	148.11	149.66	148.35
DAY TWO (Time of sensor indicator at filled level in seconds)						
Sensor A (2litres)	44.44	44.00	44.84	44.07	44.88	44.44
Sensor B (6litres)	88.59	86.72	86.78	86.38	86.56	87.00
Sensor C (12 litres)	148.26	146.45	144.39	145.50	146.10	146.14
DAY THREE (Time of sensor indicator at filled level in seconds)						
Sensor A (2litres)	44.08	44.21	44.79	44.60	44.37	44.41
Sensor B (6litres)	86.88	85.88	86.96	86.94	86.31	86.59
Sensor C (12 litres)	147.38	145.51	148.25	145.87	145.15	146.43
DAY FOUR (Time of sensor indicator at filled level in seconds)						
Sensor A (2litres)	44.96	44.07	44.09	43.72	43.40	44.048
Sensor B (6litres)	88.43	86.30	87.70	89.84	85.74	87.60
Sensor C (12 litres)	146.36	145.23	144.28	147.45	144.40	145.54
DAY FIVE (Time of sensor indicator at filled level in seconds)						
Sensor A (2litres)	43.80	44.20	44.62	44.28	44.88	44.35
Sensor B (6litres)	87.74	86.23	86.75	86.06	86.56	86.66
Sensor C (12 litres)	147.33	144.52	149.11	145.20	146.10	146.45

Table 1 shows the time it takes to fill each container and the sensing time when the pump is in operation. Sensors A, B and C contain 2 Litres, 6 and 12 Litres respectively. The average sensing time for a period of five (5) days are presented as captured in Table 1. These values were plotted against each volume to determine the rate of volume as the slope.

Table 2:Volumetric rate at different sensing time when pump not in operation with the sensor

DAY ONE						
	1st Reading (S)	2nd Reading (S)	3rd Reading (S)	4th Reading (S)	5th Reading (S)	Average Time (S)
Level A (2litres)	41.50	44.77	44.95	43.40	44.09	43.74
Level B (6litres)	90.86	86.15	87.63	84.74	85.70	87.01
Level C (12 litres)	147.08	145.36	148.28	144.40	144.28	145.88
DAY TWO						
Level A (2litres)	43.72	44.90	43.72	43.40	44.71	44.09
Level B (6litres)	86.77	89.84	85.74	85.74	86.73	86.96
Level C (12 litres)	147.38	145.51	147.45	144.40	148.11	146.57
DAY THREE						
Level A (2litres)	44.20	44.62	44.28	44.08	44.21	44.27
Level B (6litres)	86.23	86.75	86.06	86.88	85.88	86.36
Level C (12 litres)	144.52	149.11	145.20	147.38	145.51	146.34
DAY FOUR						
Level A (2litres)	44.84	44.07	44.88	46.61	44.71	45.022
Level B (6litres)	86.23	85.49	86.62	88.59	86.73	86.73
Level C (12 litres)	148.78	145.50	146.10	152.33	148.11	148.16
DAY FIVE						
Level A (2litres)	44.53	44.17	44.20	44.44	44.07	44.28
Level B (6litres)	87.11	86.38	86.23	87.59	86.38	86.73
Level C (12 litres)	147.45	145.58	144.52	148.26	145.50	146.26

The results of the pump flow rates were obtained by solving for flow rates in each process. The average flow rate from the time it takes to fill water from 0-2 litres is 0.094L/S when the pump is coupled with the control system and 0.094L/S when not in operation with the system. 0.101L/S and 0.100L/S respectively for the average flow rate from the time it takes to fill from 2 litres to 6 litres, having a difference of 0.001L/S. The actual flow rates when sensor is used and when not in used were obtained graphically as presented in Figures 3 and 4 . The values are 0.096L/S and 0.100L/S respectively, having a difference of 0.004L/S.

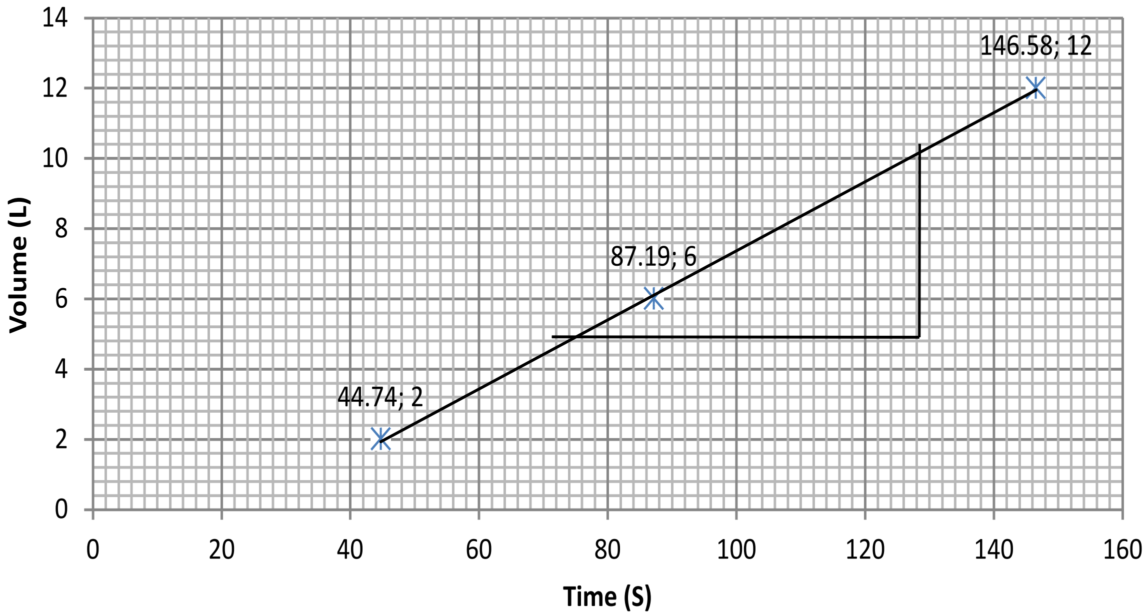

Figure 3: Graph of Volume against Time when pump is in operation with the Automatic Water Control System

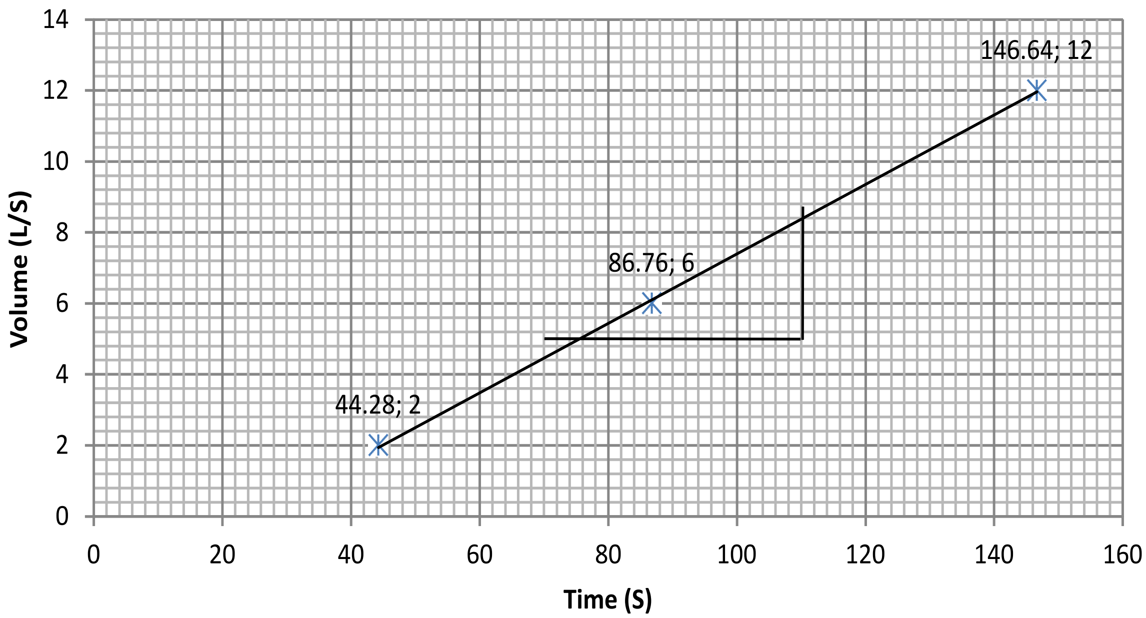

Figure 4: Graph of Volume against Time when pump is not in operation with the Automatic Water Control System

Figures 3 and 4 show that as the time of pumping increases the rate of flow decreases with an increase in the volume of water to be filled in the container, when the pump is in operation and when not in operation with the automatic water control system. The slope of the graphs (Figures 3 and 4) represents the actual volumetric rate when the sensor is in operation and when not in used. These values are 0.096L/S and 0.100L/S respectively, having a difference of 0.004L/S, representing 0.4% deviation.

4.0 CONCLUSION

The results of the study are shown in appendixes I- VI with the red LED display indicating at low level of fill, yellow LED at half-filled and green LED at full capacity with pumped water. With the use of automatic water controller, the pump flow rate indicates an average time of 278.51

seconds to fill a twelve litres tank, and 277.68 seconds to fill same twelve litres tank without the use of the control system. The slope of the graphs signify the actual flow rate achieved by the pump when coupled to the control system which is 0.096 L/S, and 0.100 L/S when not coupled to the control system. These results have significantly shown that the automatic water control system has no effect on the performance of the pump, but rather, helps to prevent over use of the pump and regulates how the pump is being used. The study recommends the use of Radio Frequency (RF) technology in subsequent research to determine the interaction between the controller and the water level sensor in pumping operation.

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Appendices

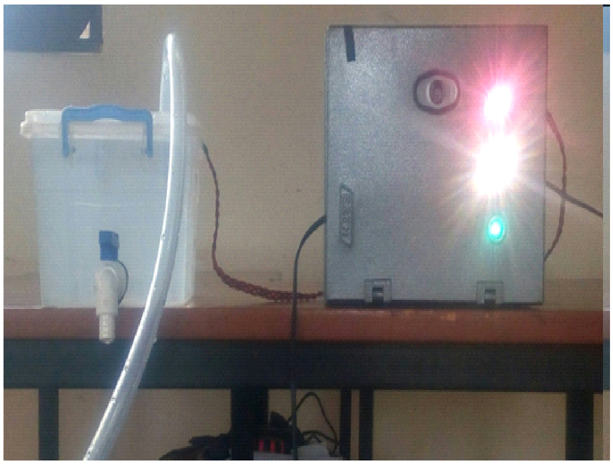
Appendix I:Automatic Water Level Indicator and Control System

Appendix II: Control System Panel, Centrifugal Submersible Pump and Water Tank

Appendix III: Assembled Control System Circuit in the Electrical Panel Box

Appendix IV:Red LED- Level 1 Reached Indicating the Tank is slightly Filled

Appendix V:Yellow LED- Level 2 Reached Indicating the Tank is Half Filled



Appendix VI:Green LED- Level 3 Reached Indicating the Tank is fully Filled