Online Monitoring and Controlling Water Plant System Based on IoT Cloud Computing and Arduino Microcontroller

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Abstract

Water is basis of the existence of life on earth and its invaluable because it's an essential requirement for all the human beings but, presently water preparation and processing systems are suffering from different problems such as real-time operations problems, loss of large amounts of water in the liquidation and distribution operations, less amount of water sources, i.e. The increase in water problems coincides with the increase in population numbers and residential areas such as (water distribution, consumption, Interrupted water sources problems as well as water quality). Therefore, to eliminate these problems and make more efficient water systems, effective and reliable there is necessity for accurate monitoring and proper controlling system. In this paper, we are focusing on the design of water system in real-time and on the continuous monitoring of water based on IoT cloud computing and Arduino microcontroller. Water system with proper control algorithm and continuous monitoring any place and any time makes a stable distribution so that, we can have a record of height of water in tanks and we can change the devices status in the plant. Internet of things is a network of physical connected objects equipped with software, electronics circuits, sensors, and network connection part which allow monitoring and controlling anywhere around the world. Through using cloud computing proved by free severs, the water system's data continuously is uploaded to cloud allowing the real time monitoring operation by the use of sensors and microcontroller (Arduino) as Minicomputer to control and monitor the system operation from cloud with efficient (client to server) connection.

Keywords: Arduino Microcontroller, Internet of Thing, Cloud Computing, Level Sensors, Pump, Relays, Water Processing.

الخلاصة:

يعد الماء أساس وجود الحياة على كوكب الارض ولا يقدر بثمن لأنه يمثل الحاجة الأساسية لجميع البشر، ولكن في الوقت الحاضر، تعاني أنظمة إعداد ومعالجة المياه الكثير من المشاكل المختلفة مثل مشاكل عمل الانظمة بالوقت الحقيقي، وفقدان كميات كبيرة من المياه في عمليات التصفية والتوزيع وتناقص مصادر المياه مثل انخفاض معدل سقوط المطر. وتزداد مشاكل المياه مع الزيادة في أعداد السكان والمناطق السكنية منها مشاكل توزيع المياه والاستهلاك وانقطاع مصادر المياه وكذلك جودة المياه. ولهذه فان القضاء على هذه المشاكل يجعل أنظمة المياه أكثر كفاءة وفعالية وموثوقية اذ ان هناك ضرورة لمراقبة الدقيقة ونظام تحكم سليم. في هذا البحث سوف نسلط الضوء على تصميم نظام لمراقبة المستمرة على عمليات معالجة وتوزيع المياه بالوقت الحقيقي المستندة على تقنية الكمبيوتر السحابي والمتحكم الدقيق من نوع (أرد ينو). ان انظمة المياه مع الخوارزمية التحكم المناسبة وامكانية المراقبة والرصد المستمر من أي مكان وفي أي وقت يجعل عملية توزيع المياه منتظمة بحيث أننا يمكن أن نسجل ارتفاع مستوى المياه في الخزانات وأيضا تغيير حالة الأجهزة في المحطة. إنترنت الأشياء هو عبارة عن شبكة من الأشياء المادية مرتبطة مجهزة ببرامج ودوائر الكترونية وأجهزة الاستشعار ودوائر لاتصال بالشبكة بحيث يسمح بعمليات الرصد والمراقبة في أي مكان في جميع أنحاء العالم. ومن خلال استخدام الكمبيوتر السحابي الذي توفره الخوادم مجاناً فان بيانات منظومات المياه يتم تحميلها بشكل مستمر إلى السحابة ممكنا بذلك الرصد في الوقت الحقيقي لعمليات باستخدام أجهزة استشعار والمتحكم الدقيق من نوع (أرد ينو) والذي يعتبر كالكمبيوتر مصغر لمراقبة ورصد وتشغيل النظام من سحابة مع كفاءة الاتصال باستخدام بروتكول (العميل إلى الخادم).

الكلمات المفتاحية: المتحكم الدقيق (ارد ينو)، انترنت الأشياء، الكمبيوتر السحابي، حساسات المستوى، مفاتيح الكهربائية، المضخات، معالجة المياه.

1. Introduction

In recent years, there are surveys about water systems because it has become a big problem because of the fewer water sources and the increase in population. The

indiscriminate distribution of water for irrigation systems had a role in the decrease of agricultural activity and people still suffer from this issue. They don't have sufficient amount for their daily requirements. As a result of lack of water systems interact with modern technology, the monitoring operations and controlling of water amounts are unavailable so it can't be managed properly (Venkata , 2015). Based on this, some regions in cities or villages get water where other some regions or villages can't thus, there is a demand for real-time continuous monitoring with a reliable control algorithm, scheduling of water supply and suitable distribution. These things can be solution to problems such as the excessive consumptions, interrupted water supplies, tanks overflow, and pipelines leakages. Water is the main requirement of each human. Everybody has to keep the water (Khaled , 2013). Without continuous monitoring and controlling, several problems are expected to occur. For example, the overflow of these overhead tanks can happen and result in losing great amount of water. Pipelines can be damaged due to overflow in the pipelines with high pressure. All mentioned problems earlier could occur because the water system operates without real-time monitoring, and because of the manual job and the lack of labour (Ejiofor , 2013). In to this project, we took into consideration several studies to have a better understanding of water systems processing , water distribution, and problems related to these systems. By focusing on problems in traditional systems, there is a need to design and develop a low-cost computing system device with real-time monitoring and controlling of water processing and distribution systems based on Internet of things (IoT) technology. IoT is a term refers to a world of connected things where can sense, connect and share information about billions of things. All these things are linked over public or private Internet Protocol (IP) networks. These interconnected things have data collected at regular intervals, the data are then analyzed to be used for initiating action, allowing a wealth of intelligence for planning, decision-making, and management (Tiia, 2015).

2. Proposed System Design.

Before viewing the proposed system, let us clarify how water arrives in residential areas and houses. In general, water stations usually depend on the water sources such as lakes, rivers, and wellhead. From these sources, water is pumped from pumps warehouse to water treatment plants by pipelines. Water is cleaned at the water treatment plant and from there it is pumped into the tubs. The tubs are the warehouse for the treated water. Now, water is pumped from these tubs to the overhead tanks distributed around the city. The water is piped to houses and factories through the pipelines networks. In some cases, water is directly provided from the tubs to the houses. As all the cities are working on a smart city concept, our proposed system focuses on cities, where Internet of things is a new scenario for making these cities smart ones with a different application. The goal of proposed system is to build a modern generation of water systems, which is real time monitoring and controlling, flexible, efficient, and capable of monitoring and controlling the several water processes. Additionally, the system operates based on IoT concept with cloud sharing data, cloud monitoring and controlling. Figure (1) shows the proposed overall system block diagram.

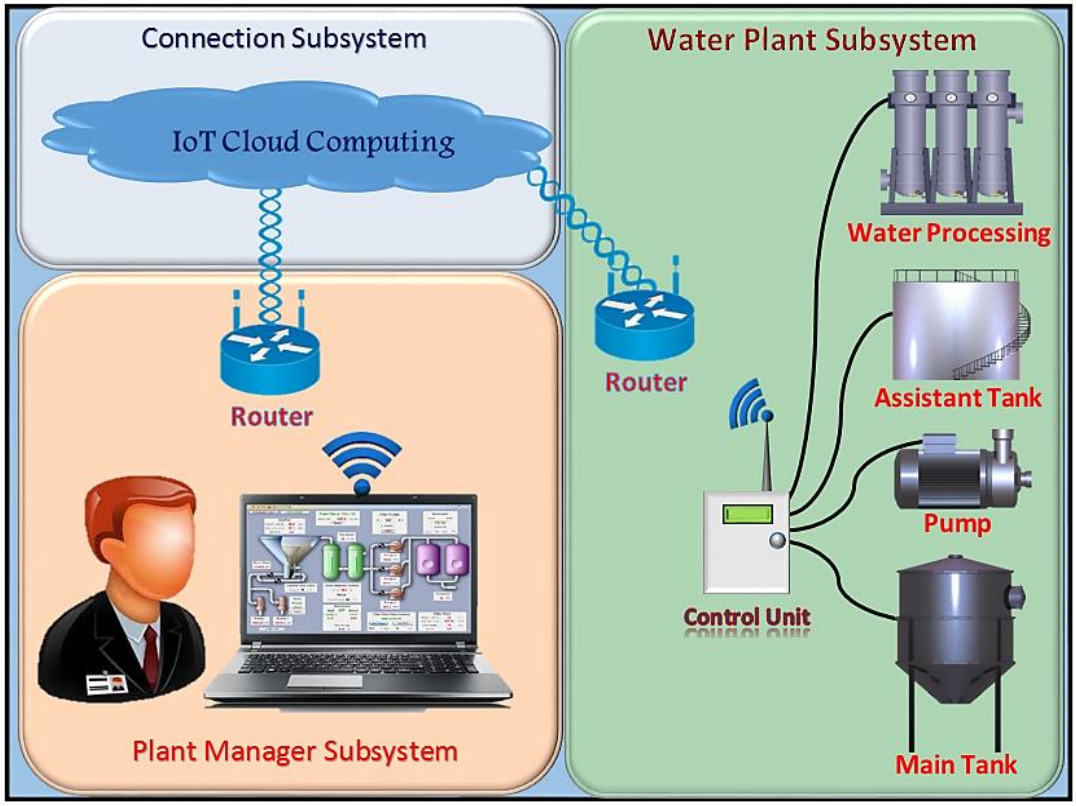

Figure (1) Overall System Block Diagram.

The system is mainly separated into three subsystems: namely water plant subsystem, connection subsystem, and plant manager subsystem.

2.1. Water Plant Subsystem.

Water plant subsystem contains water processing device, assistant tank, pump, storage tank, and control unit with its sensors, relays, as well as a router for wireless connection.

2.1.1. Water Processing Device.

The basic principle of water processing system (reverse osmosis filter system) depends on sending source water through a series of carbon block filters and a reverse osmosis velum. This system employs the water pressure for pushing water through the system. By these processes, the contaminants are collected in a brine which goes down the drain. The water processing stages of this device are shown in figure (2).

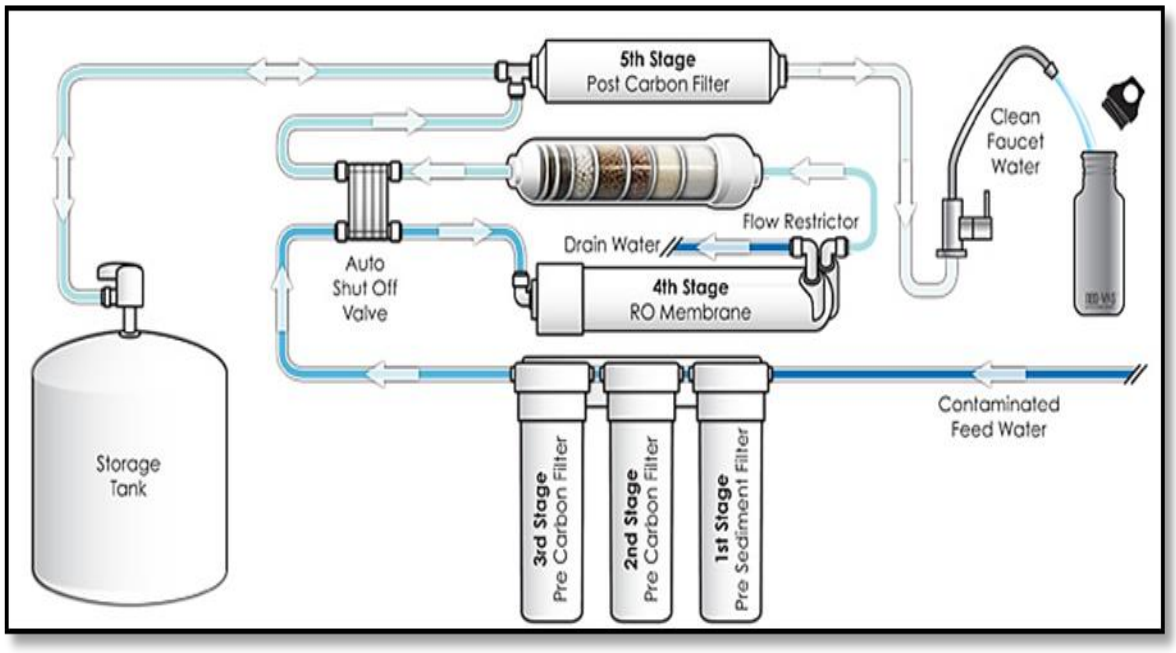

Figure (2) Block Diagram Of Water Processing Device.

2.1.2. Assistant Tank.

The assistant tank is considered as place for temper storing of water that exist from water processing device in order to pump the required mounts of water(which is determined by plant manager)to the main tank. It has the advantage of voiding the problem of unavailability of main water supply or and of avoiding the failures that may occur in the water processing device. In this project, tank with a height of 30cm has been used.

It is worth mentioning that when there is no liquid in assistant tank, the system stops the pump unit completely and gives a warning alarm.

2.1.3. Pump.

Water pump is used to pump the water from the Assistant tank to the Storage tank. Water pump in this project is shown in figure (3) has the following specifications: 12V DC supply voltage, 700mA full load current, 4M maximum height to lift liquid, and 5 bar maximum pressure.

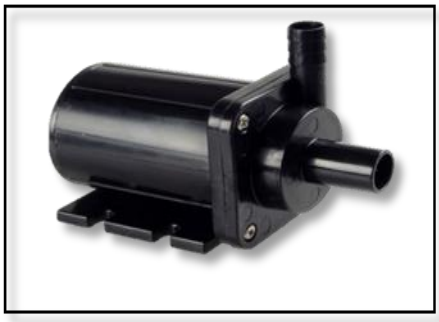

Figure (3) Water Pump.

2.1.4. Main Tank.

The main tank is considered as storing place after completing all water-processing stages where water is distributed to population areas according to amount of water

specified by the plant manager. The main tank has advantage of providing a clean water to population areas to satisfy their need. In this project, tank with a height of 30 cm has been used.

It is worth mentioning that when there is no liquid in main tank, the system forces the pump unit to pump water according to the required level with giving a warning alarm.

2.1.5. Control Unit.

The components of control unit are Arduino at Mega 2560 (microcontroller for control algorithm implementation), Yun shield (its function to communicate with Router for data transmission), ultrasonic level sensor HC-SR04 (for actual level measurement), and controlled switch (It is a relay to mandate water pump and water processing device operation according to the control signal generated by the control algorithm). All the components the operation and the control algorithm are programmed by using Arduino.cc software.

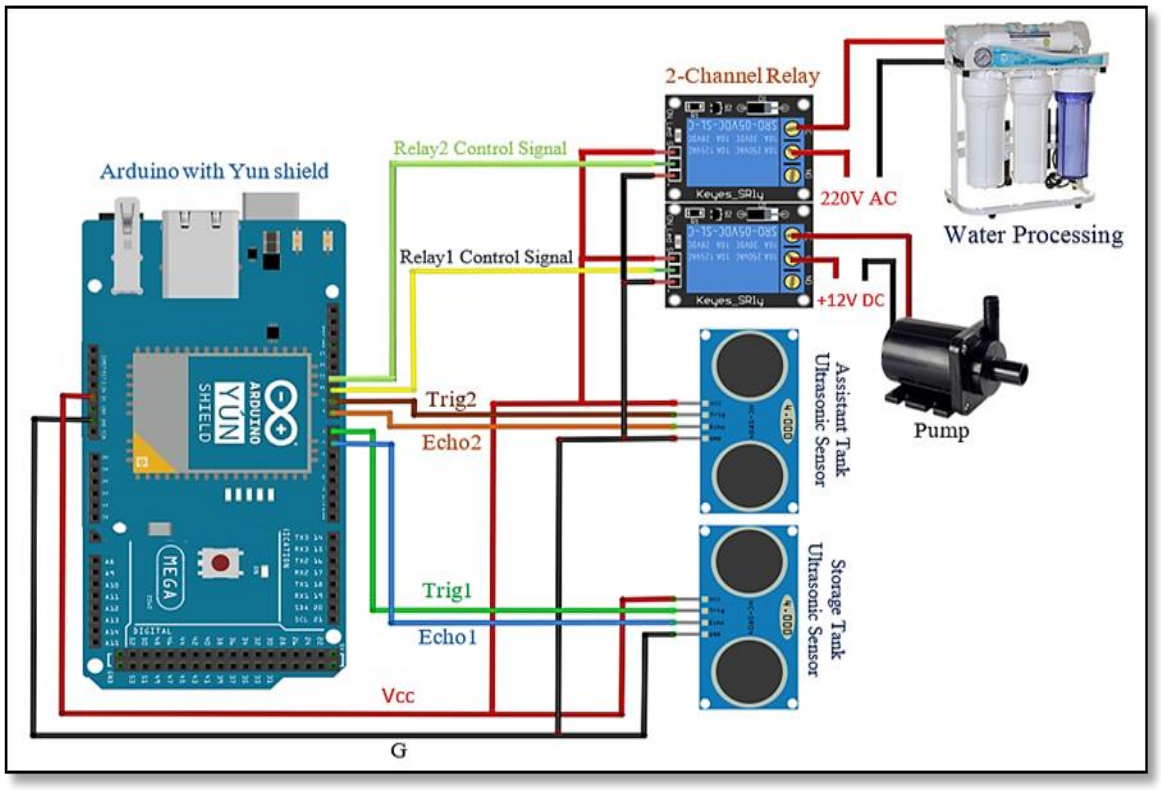

Figure (4) Hardware Components of Control Unit.

2.2. Connection Subsystem.

The aim of this subsystem is to link all the subsystems for the purpose of data transferring.

2.2.1. Router.

It provides the wireless connection with control unit of water plant system for enabling plant access through internet. Therefore, the system can be connected with IoT cloud computing to exchange information with plant manager for monitoring and controlling its operations. In this project, router has been used as it is shown in figure (5).

Figure (5) TL-WR940N Router.

2.2.2. IoT Cloud Computing.

IoT Cloud Computing is a new online managing data technology, which utilizes the internet and central remote servers for managing data and applications. By IoT cloud computing, businesses and consumers are capable of using applications without setting and accessing data from any computer within internet. This technology provides more efficient computing by centralizing processing, the data storage and the bandwidth.

In this project, IoT Cloud Computing provides facility connection for sharing the data of water plant subsystem and plant manager subsystem. Therefore, plant manager can interact with the remote water plants providing real time monitoring and controlling at anytime and anywhere. IoT Cloud Computing has been built cloud by free servers and it is programmed by vb.net 2013.

2.3. Plant Manager Subsystem.

Plant manager subsystem consists of one expert person who is able for online administration of the plant. He is connected to the internet through the router. That person has specific GUI as it is shown in figure (6) with a specific user name and password for login to the system. Through sharing data on the cloud, plant manager can monitor and control the water plant parameter.

In this project, the plant manager GUI is designed and programmed by vb.net 2013, which provides the ideal environment for the design of such programs. It consists of interactive interface, which gives a detailed and identical picture of the reality of devices in the remote water plant. Therefore, plant manager can interact with the plant parameters behavior and control it.

Figure (6) Plant Manager GUI.

3. System Operation.

The system consists of plant manager GUI is connected to IoT cloud for remote monitoring and controlling, and to the prototype water system that consisted of control units connects to IoT cloud through router to send data to or to receive commands from plant manager. So in order to clarify the system operation steps let us explain it in the following steps:

- First, the plant manager chooses the operation mode of plant, which is either automatic or manual.
- When plant manager chooses manual operation, the control unit sends back to plant manager GUI to specify the operation requirements of control unit.
- Plant manager specifies water processing device operation, assistant tank level, pump operation and main tank level.
- Plant control unit receives plant manager commands wirelessly and starts the operation of control algorithm to allow the water plant response to these commands.
- When water level in assistant tank reaches to the required level, the control unit sends control signal to the water processing device to turn off.
- When water level in main tank reaches to the required level, the control unit sends control signals to pump unit to turn off.
- If plant manager chooses an automatic operation, the control unit manages thr water plant system automatically with certain levels and certain scenario.
- The whole data is displayed numerically and graphically in plant manager at GUI screen.
- If the internet failed in connection, all water plant subsystems will operates according to the last commands received.

4. System Features.

The features of the system can be summarized in following points:

- We have a real time system with continuous monitoring and controlling.

- Plant manager can monitor and control at anytime and anywhere due to the use of the internet for sharing data around the world.
- Plant control unit can be reprogramed wirelessly.
- It is possible to monitor and control water plants in different areas around country.
- All water plant parameters appear in the plant manager GUI of the systems in which the appropriate action is applied.
- Notes panel is considered in the system, which gives alarms and parameters status of water plant.

5. Result.

In this system, the using of Arduino microcontroller and IoT cloud computing for monitoring and controlling water plant with feedback, having passed the necessary experiments with the other components interfaced to it, is hereby viewed. With this implemented system which is shown in figure (7), remote monitoring and controlling of the water level in an over-head tank are possible. The system also enable us to switch on the water pump when the tank is empty and to switch off the same pump when the tank is full without any need for human intervention or any other devices in water plant. Therefore, the case of water wastage is eliminated as well as the abrupt cut-off of water supply is also eliminated.

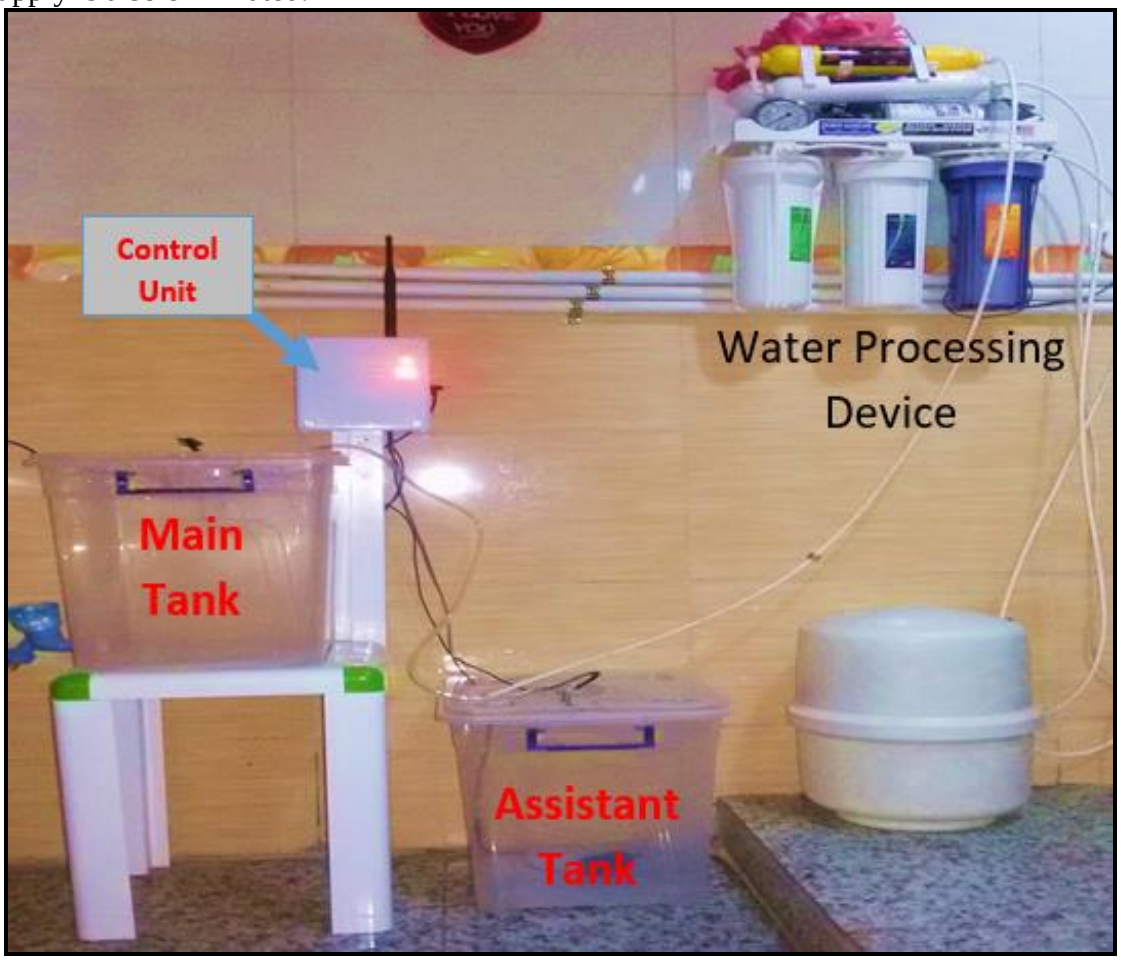

Figure (7) Hardware of the System.

At first, we select the manual mode operation of plant system and we insert the assistant tank level and the main tank level by activing the operation through the pressing ON/OFF button for both pump and water processing device. Therefore, the pump and water-processing device are activated in GUI to perform the manager commands as shown in figure (8).

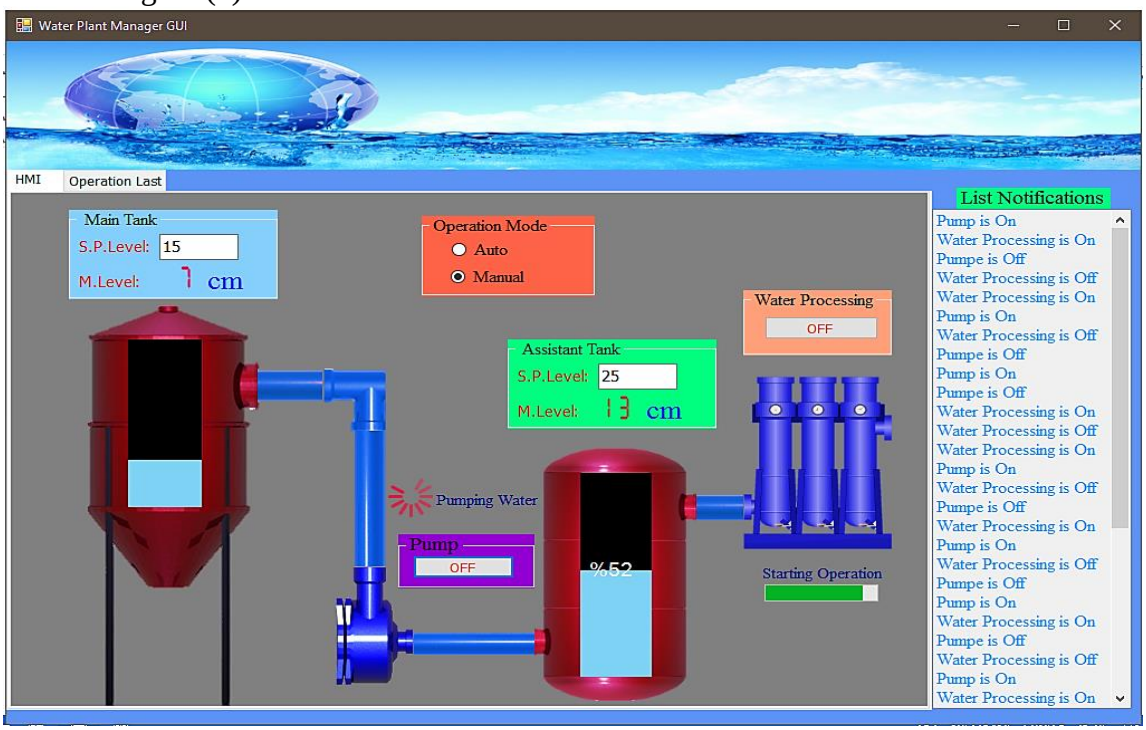

Figure (8) Manual Mode Operation of Plant with Processing Case.

The control algorithm operates to oblige the water plant of responding to the commands selected by the plant manager. Therefore, the system operates normally until achieve the required commands are achieved as shown in figure (9)

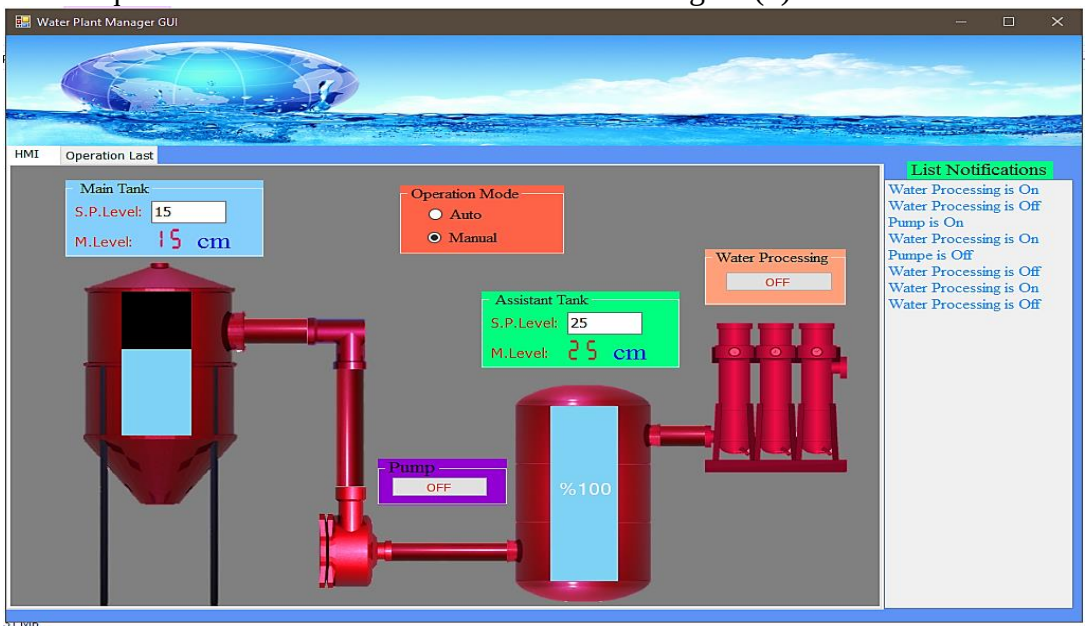

Figure (9) Plant Manager GUI with Finishing the Required Commands.

When we select the automatic mode operation, the control algorithm starts manageing water plant automatically with a specific scenario that is programmed to perform the water plant system, as it is shown is figure (10).

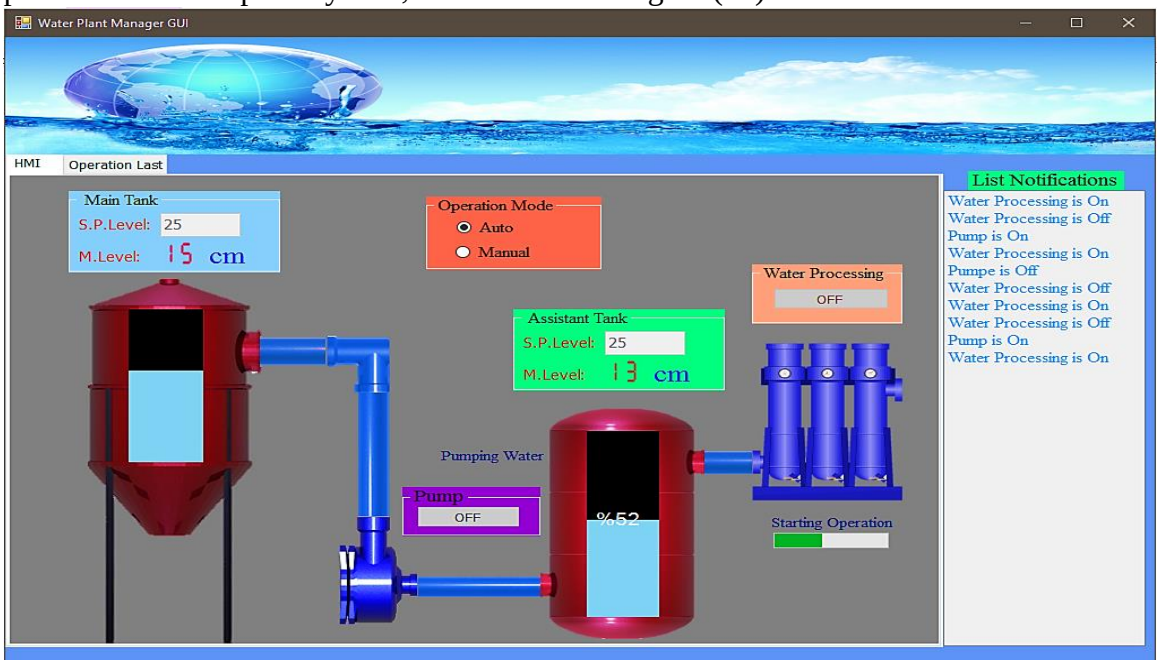

Figure (10) Automatic Mode Operation of Plant.

6. Conclusion.

The proposed system based on Internet of Thing concept as a new idea applied in smart cities. By using this system technique, the secure, real-time monitoring and accurate control are possible. It is not required to go to the plant for monitoring. Therefore, the manual jobs are reduced. It makes the water plant system more flexible, efficient, accurate, and low cost. As well as, all water plant systems in different places in country can link with a central cloud and they can be managed from one central remote place or disturbed administration on the different central remote places in an easy manner.

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