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# Smart Sustainable Water Monitoring System via Internet of Things (IoT) for Water Retention Pond UiTM Cawangan Johor, Kampus Pasir Gudang

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**Abstract:** Water retention ponds developed in UiTM Pasir Gudang is used to accommodate the overflowed water from the campus facilities. Overflowed water is accumulated into this water retention pond and will flow to other water sources. Water from the water retention pond has potential to contaminate other water sources as well as the environment. To maintain the water retention pond, a sustainable water monitoring system with an integration of internet of things (IoT) technology is designed and implemented. A fully developed integrated IoT monitoring system is presented in this research paper. The developed system will assess the water parameter such as pH and water temperature as well as water quality to serve as the water health indicator. This system includes a pH sensor, temperature sensor, rain sensor, sustainable power supply, wireless frequency data transmission module, and IoT data acquisition system in the base station. After the water data process has been performed and verified, the authorities will be notified of the unhealthy water condition. The developed system also allows any person or authority to monitor the water quality in that environment from anywhere. As a result of the collected data for water data parameters, the developed system provides an efficient water parameter monitoring system. Thus, early actions can be taken to reduce any harmful effects to the environment due to poor intervention.

**Keywords:** Internet of Things; Water Monitoring; Water Security; Online Notification; Water Pollution

## 1. Introduction

Water pollution has recently caused concern throughout the country, particularly in Pasir Gudang. As is well known, the most serious concern in Pasir Gudang is the severe water pollution. Water pollution seems to have the most impact on the ecosystem, and majority of the pollution is caused by untreated or uncontrolled water quality. Untreated and hazardous water could lead to a number of deaths every year (Geetha & Gouthami, 2016). The most recent pollution event occurred in Pasir Gudang is a result of chemical waste from one of Johor's rivers, and this phenomenon continues. Main factor of this continuous water pollution is because there are no appropriate approaches currently being

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implemented to monitor the behaviour change of the nature, while the level of contaminations in the water keeps rising (Encinas et al., 2017). The water ecosystem will also be jeopardized if the required parameters for controlling water quality to its specific water quality index are not monitored on a regular basis. The current existing method is a conventional manual sampling work which requires personnel to be at the polluted area or the water resource to measure the required water quality parameter. Like many other industries, this water monitoring sector such as the water treatment and water provider sector also face the problem of staffing shortage. There are limited numbers of manpower for fieldwork checking at the water sources and huge number of these water plants or water sources are in developed countries. Other than these limitations, early interventions are not taken in planning to reduce or distinguish the effects to the environment that could be harmful to the society. Finally, this developed Smart Water Monitoring System will resolve the difficulties of monitoring the water quality based on selected criteria. As a result, this system will identify any undesirable scenario that occurs on the located water source. The developed system will update the parameter value and notify the authority or person in charge if the selected parameter value for this system detects an undesired value. Early action can be taken to address the water quality to make sure it is still clean and under control within the required specification.

## 2. Water Pollution

The widespread provision of better water quality and quantity is currently gaining prominence in our nation due to the current population growth trends. The united nation has announced water as one of main clusters in agenda for sustainable development. This is a crucial matter for all countries especially to our developing country to take action in achieving better future with good health and socio economy. There are 17 SDGs integrated and for this water management, two SDGs are involved which is SDG 6, clean water and sanitation and SDG 14, life below water as shown in Figure 1 (World Health Organization & UNICEF, 2017). These SDGs goals are to ensure availability and sustainable management of water and sanitation for all in the future. Thus, all creativity, technology and financial resources to achieve the SDGs are required from all society (World Health Organization & UNICEF, 2017).


**Fig. 1 - The SDG 6 (Clean Water and Sanitation) in provide sustainable management of water**

Therefore, the concern about water quality is necessary in this water system to improve the sustainable water supply which can prevent any potential unwanted environmental problem. Latterly, there is a large amount of uncontrolled quality water with unknown condition being discharged into streams and feed other water sources which can cause risky water quality in the future and might lead to water pollution. Currently, water pollution is increasing as more than 80% of wastewater resulting from human activities are being discharged into the stream without proper treatment (Geetha & Gouthami, 2016). The main cause of these water pollutions is the lack of a proper mechanism for monitoring the water condition (Encinas et al., 2017). Other potential issue is the need of the expansion of new water source due to population growth and demand from industrial sector in getting freshwater resources (Geetha & Gouthami, 2016) (Zhou et al., 2018). Therefore, this water quality is one of important parts in integrated water resources management.

### 2.1 Water Parameter

The water quality standard used in our country by the Department of Environment (DOE) is from the Water Quality Index (WQI) standard and National Water Quality Standard for Malaysia (NWQS) as shown in Table 1. The water quality index (WQI) is used to categorize the water condition level into several classes, which are Class I, IIA, IIB, III, IV, and V, using scientific-based parameters. This identified WQI monitors the current water condition as well as after each water source undergoes any water treatments. These water qualities are comprised of several parameters, including temperature, turbidity, electrical conductivity, and pH value (Madala et al., 2018). Therefore, the standard of WQI is used in classifying the lake water condition.

**Table 1 - National Water Quality Standards for Malaysia**

| Parameter | Unit | Class | | | | | |
|---|---|---|---|---|---|---|---|
| | | I | IIA | IIB | III | IV | V |
| Ammoniacal Nitrogen | mg/l | 0.1 | 0.3 | 0.3 | 0.9 | 2.7 | >2.7 |
| Biochemical Oxygen Demand | mg/l | 1 | 3 | 3 | 6 | 12 | >12 |
| Chemical Oxygen Demand | mg/l | 10 | 25 | 25 | 50 | 100 | >100 |
| Dissolved Oxygen | mg/l | 7 | 5-7 | 5-7 | 3-5 | <3 | <1 |
| pH | - | 6.5-8.5 | 6-9 | 6-9 | 5-9 | 5-9 | - |
| Colour | TCU | 15 | 150 | 150 | - | - | - |
| Electrical Conductivity | µS/cm | 1000 | 1000 | - | - | 6000 | - |
| Total Dissolved Solid | mg/l | 500 | 1000 | - | - | 4000 | - |
| Total Suspended Solid | mg/l | 25 | 50 | 50 | 150 | 300 | 300 |
| Temperature | ºC | - | Normal + 2 ºC | - | Normal + 2 ºC | - | - |
| Turbidity | NTU | 5 | 50 | 50 | - | - | - |

The water quality of a certain water source can be classified based on the quality index specification by measuring the physical and chemical parameters of the water. The pH chemical based parameter and turbidity physical based parameter are measured in this developed system to assess the status of the water condition. As a result, it is possible to determine the water quality of water retention in UiTM Cawangan Johor, Kampus Pasir Gudang by monitoring the changing value of the parameter. The water can be polluted by various activities such as improper domestic waste management that could produce unwanted hydrochemical substance. In indicating the water hydrochemical characteristic, pH value measurement can be used. A study was carried out in Dianchi main river, Yunnan, China to monitor the effect of pH value based on human activities (Feng et al., 2017). Result showed that the river water pH value is higher (6.85 to 7.77) when more human activities are involved at the downstream and lower when there are less activities. This change on the pH value specifies the availability of the contaminant bacteria in the water ecosystem where this pH value is often correlated to the presence rate of the bacteria (Zulkifli et al., 2018). Other parameter that is used in identifying the water quality is turbidity value where each water source can contain suspended solid which consist of many particles at different sizes. Due to human activities such as construction which can interrupt the land ecosystem, it can also lead to the unwanted level of sediment streaming into water caused by storm or rain water runoff and worsen the water condition to become cloudy. This can also lower the water quality and contribute to high turbidity level (Lee et al., 2016)(Njue et al., 2018). As a result, due to the availability and cost of the module sensors, the parameters selected for this project are pH and turbidity. These parameters are sufficient to identify the changing state of the lake water in real time and they will enable the local authorities to monitor the water ecosystem. By implementing the water quality monitoring systems which can identify and localize the pollution sources, this can facilitate accurate emergency treatment and reduce harmful influences (Pavana & Padma, 2016).

## 2.2 IoT Technology used for Water Quality Monitoring System

As technology advances and Malaysia moves toward the Industrial Revolution 4.0, IoT technologies have seen an impact on various digital systems, particularly the water quality monitoring system. There are several research and projects integrating this technology in monitoring the water condition and quality. The related research works that utilized IoT as the platform to monitor the water quality are shown in Table 3.

**Table 2 - Summary of related IoT-based water quality monitoring system**

| Authors | Measured Parameters | Technology | Application |
|---|---|---|---|
| (Encinas et al., 2017) | pH, temperature, dissolved oxygen and conductivity | Using short range Zigbee protocol with IEEE802.15.4 specification as the medium access layer (MAC) and PhysicalLayer (PHY) | To monitor water quality in multiple ponds with mobile-based sensor node. |
| (Simic et al., 2017) | air temperature and relative | Ethernet LAN | To monitor the air and water quality. |

| | | | |
|---|---|---|---|
| | humidity (RH), presence of volatile organic compounds (VOC) as well as water temperature and pH level | | |
| (Xu et al., 2016) | dissolved oxygen, pH, temperature and conductivity | Developing a novel micro-electrode array (MEA) sensors using ink-jet printing technology (IPT) | To monitor the water quality during water and wastewater treatment processes. |
| (Saravanan et al., 2018) | pressure, pH, level, and energy | GSM | To measure water quality using sensors for prevention of water pollution. |
| (Myint et al., 2017) | pH, water level, turbidity, carbon dioxide (CO2) on the surface of water and water temperature | FPGA with Zigbee Communication Protocol | A reconfigurable smart sensor interface device for water quality monitoring system in an IoT environment. |

With the current advancement of IoT technology, this project might produce a complete solution of water quality monitoring and prevention system. With the utilization of a wireless storage data system, it can be utilised to sense pH and turbidity in order to identify the water health status. The sensor network will be attached to an ultra lightweight embedded microcontroller, which will process the data and transmit it to the IoT Dashboard. The system will be equipped with an identification location, and authorities will be notified of the particular location of the affected area before taking the necessary procedures to rehab the water. As a result, this solution will assist authorities in taking appropriate steps to manage the impacted area's water quality.

## 3. Development of Smart Sustainable Water Monitoring System via Internet of Things (IoT) for Water Retention Pond.

The Power Supply Unit, Process Controller Unit, Sensor Network System, IoT Dashboard, and Notification Alert System are the five key components in the development of this IoT-based Water Quality Monitoring System. Each component is set up with proper specifications that encompass all aspects such as the electrical or electronic standard as well as the weather resistant requirement since the system hardware is located near to water source. Figure 2 depicts the system entire block diagram architecture.

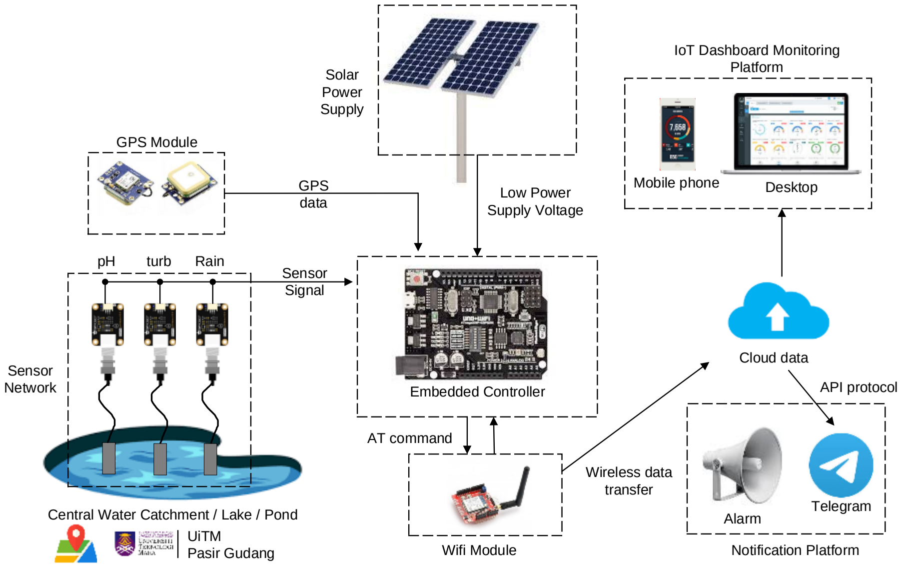


**Fig. 2 - Architecture of the Smart Sustainable Water Monitoring System via Internet of Things (IoT) for Water Retention Pond**

### 3.1 Sustainable Solar Power Supply System

The developed system hardware is powered by a solar power supply system that consists of a 10W tiny solar panel, a solar charger, a power pack, and a low voltage converter. The voltage regulator is used to supply varying voltage to all of the components, including the embedded controller, sensor network, and warning system. The solar panel is mounted to the top contact of solar in order to obtain maximum power for the battery. According to estimates, the power storage could provide enough power to the entire network to perform at optimal voltage and current.

### 3.2 Chemical and Physical Sensory Network

As to determine chemical and physical parameter of the water, a set of sensory network is developed and installed at the location. The sensor network consists of several sensors to determine the quality and behavior of the water and the sensors involved are a pH sensor, Turbidity sensor, and rain condition sensors. In getting the pH value of the measured water, an analog pH sensor is used where the output of this sensor is ranging from 0 (acidic) to 14 (alkaline). The turbidity sensor measures the water condition by measuring the level of turbidity of the water. It is able to detect suspended particles in water by measuring the light transmittance rate where it changes with the amount of total suspended solids (TSS) in the measured water. The higher the TTS in the water, the higher the liquid turbidity level. The sensor's analogue and digital values are processed by the utilized controller to obtain the exact process value of the parameter specified. The embedded controller AtMega328p is implemented as the main controller in this project to process all of the data parameters from the sensors. The C programming with the Arduino IDE software is used to read the analogue sensor value data and then digitalize the required parameter value to the exact unit value at the setup time intervals via the ADC. The controller is also coupled with the ESP wireless module, allowing it to communicate with all essential process parameter data to the cloud storage for Big Data Analysis and data visualisation on the IoT dashboard platform. All water parameter data is wirelessly and instantly updated during each required setup period, enabling any authorised person to monitor it any time and from any location.

### 3.3 Internet of Things Wireless Data Acquisition Dashboard

The designed Internet of Things Wireless Data Acquisition Dashboard developed for this project is to visualise all of the data processed and transmitted from the system. The data is shown visually in form of gauge and a chart. The actual information, such as pH value status, turbidity level status, weather condition, and the location of the measured water source, is shown on the designed dashboard. This Real-Time Smart Sustainable Water Monitoring System is equipped with an alert notification system, which notifies the authority if the controlled parameter, such as pH, is not in the specified condition or threshold.

## 4. Resultant Data of The System Implementation

The developed system is installed at the water retention in UiTM Cawangan Johor, Kampus Pasir Gudang as shown in Figure 3. Some data was recorded and displayed via the developed Internet of Things Wireless Data Acquisition Dashboard. All the required data is stored in the cloud data storage under Google data storage for big data analysis. The collected data is shown in Figure 4. All the required chemical and physical parameter which are pH, turbidity, rain indicator and the location are displayed on the developed dashboard as shown in Figure 5.

**Fig. 3 - Real System with sensory network at Field implementation Water Retention in UiTM Pasir Gudang**

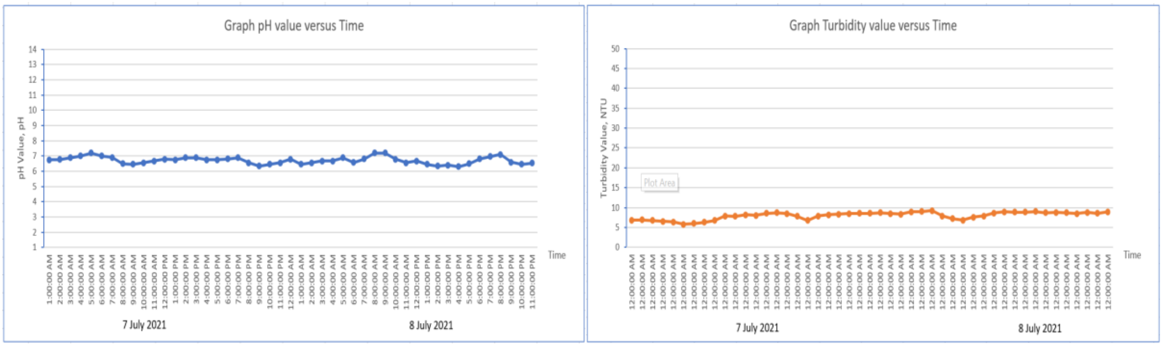


**Fig. 4 - Data collected for 2 days from 7th to 8th July 2021**

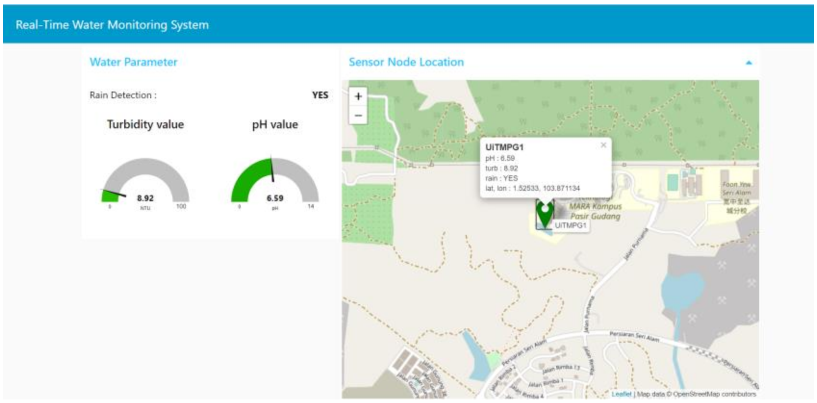


**Fig. 5 - The developed Real-Time IoT Dashboard**

According to the collected data, as shown in Figure 4, the developed system provides precise water parameter data that can be used for water data monitoring and compared to the water quality index in monitoring the water health status. This study is limited to the pattern monitoring of pH, turbidity, and rain accessibility at the water retention in UiTM Kampus Pasir Gudang and for a short period prior to the COVID-19 epidemic and the Malaysian government's Movement Control Order. More research is necessary to address difficulties related to the acquired selected parameter level values. This experiment can be enhanced by observing more water parameters to assess the quality and well-being of this water retention in better detail.

## 5. Conclusion

In this paper, the design and development of the Smart Sustainable Water Monitoring System via Internet of Things (IoT) for pH, turbidity and rain detection at water retention in UiTM Cawangan Johor, Kampus Pasir Gudang, Johor is developed and presented. The deployed system consists of pH sensor, an embedded system with the ATMega microcontroller implementation, together with the wireless module and data storage. The output pattern of the pH and turbidity level at this lake shows the current state of the water condition for the particular ecosystem. This indicates the water retention health status. Thus, the system could benefit the society surrounding the installed system by monitoring the water condition concurrently and alerting if any undesirable conditions occur in that water retention pond. Furthermore, this system can be installed in any type of water resource, providing a better water monitoring solution for better water resources. Furthermore, more data is needed and should be anticipated to be addressed in future research work for water health status to sustain a better water retention and its ecosystem.

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