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IoT Based Water Tank Level and Turbidity Detection and Monitoring System

Ilya Suhaida Mohamed Jumaiedy[1], Azeanita Suratkon[1]*

[1] *Faculty of Civil Engineering and Built Environment*
Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, 86400, MALAYSIA

*Corresponding Author: azeanita@uthm.edu.my
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Abstract

Addressing the need for efficient water monitoring in terms of volume and turbidity in residential settings, an IoT-based solution is proposed. Utilizing Blynk apps for smartphone integration, the system employs ultrasonic and turbidity sensors to accurately measure water levels and quality in residential tanks. The collected data is transmitted to a microcontroller, processed, and displayed on a smartphone for user convenience. The project focuses on comprehensive design, prototype development, and usability analysis, aiming to promote water conservation, optimize tank management and ensure a continuous supply of clean water. The user-friendly interface enables real-time monitoring and customizable alerts, empowering homeowners to safeguard their water supply and mitigate issues related to shortages and contamination.

1. Introduction

Water is a vital necessity for human survival, and the global concern for the availability of clean water is escalating. In many regions, residential water supply relies on stored water in tanks, particularly in rural or semi-urban areas. Unfortunately, this stored water is susceptible to contamination from various sources, including microbes, chemicals, and physical agents. Additionally, sediment accumulation and algae growth in tanks pose challenges to maintaining water quality (EPA United States Environmental Protection Agency, 2002).

Water level monitoring is crucial to ensure an adequate residential water supply. Traditionally, manual techniques like using measuring rods or sight glasses were employed for this purpose. However, these methods are time-consuming, require manual intervention, and lack real-time data provision, especially in areas with difficult access to water tanks. Turbidity, a measure of water clarity, indicates the presence of suspended particles, posing health risks and reducing disinfectant effectiveness (World Health Organization, 2017). Traditional measurement methods fall short in providing real-time data, hindering effective water quality monitoring.

The advent of sensor technology has revolutionized water monitoring, offering automated systems for real-time measurements (Centers for Disease Control and Prevention, 2021). Placing sensors within water tanks enables continuous monitoring of water level and turbidity. The collected data can be transmitted wirelessly to a central monitoring system, facilitating efficient water resource management. Recent advancements have led to the development of low-cost and efficient sensing technologies, resulting in simple, portable, and versatile water monitoring systems suitable for residential deployment

Homeowners can easily implement and manage these systems, gaining accurate and up-to-date information on water quantity and quality. Moreover, these systems can promptly detect anomalies, such as chemical pollutants or microbial contaminants, empowering homeowners to take immediate action to protect their health and well-being. In conclusion, automated water monitoring systems represent a significant advancement in managing water resources, providing homeowners with the tools to efficiently and effectively oversee their water supply. The adoption of these systems is crucial for ensuring access to clean and safe water, particularly in rural and semi-urban regions, marking a pivotal step towards enhancing water quality in residential areas.

2 Literature Review

2.1 Selection of Sensor

Selecting the right sensors is vital for a water tank level and turbidity detection system, guaranteeing precise measurements, resource efficiency, and safety adherence. This choice enables automation, remote monitoring, and data-driven insights, promoting sustainable water management. Optimal sensor selection supports efficient water usage, contamination prevention, and timely interventions while facilitating system integration, cost-effectiveness, and reliable operation of the monitoring system.

2.1.1 Durian Uno V2

The project utilizes the Durian Uno V2, known for its plug-and-play simplicity, eliminating the need for complex setups and enabling immediate initiation. With a wide input voltage range, down to 3VDC, the Durian Uno is well-suited for applications with diverse power sources. Its user-friendly interface facilitates programming and operation of electrical devices through both text-based and block-based coding, making it particularly advantageous for beginners venturing into IoT and microcontroller programming (Mybotic, 2023).

2.1.2 Ultrasonic Sensor

Ultrasonic sensors gauge the distance between the sensor and an object by emitting high-frequency sound waves that bounce back to the sensor. The measurement relies on the time taken for the sound wave to return, enabling accurate distance determination. These sensors find widespread use in robotics, vehicles, and various industrial applications, offering a versatile solution for distance detection based on sound wave reflection (Mybotic, 2023).

2.1.3 Turbidity Sensor

Turbidity sensors assess the cloudiness or haziness of a liquid by passing light through it and measuring the absorption or dispersion of light by particles, detected on the opposite side. The higher the turbidity or murkiness of the liquid, the more particles present, resulting in less light transmission. This method is particularly employed in water treatment plants to gauge the quality of drinking water, providing a valuable tool for assessing and ensuring water clarity and purity (Mybotic, 2023).

2.2 Display Board

A "display board" generally denotes a surface designed for visual presentation of information or graphics and can manifest in diverse types like electronic display boards, bulletin boards, whiteboards, or signage boards. Essentially, a display board serves the purpose of showcasing information or visuals, encompassing a broad range of applications where visual communication or presentation is essential.

2.2.1 Liquid Crystal Display Module

The liquid crystal display (LCD) is a sleek, flat device containing color or monochrome pixels arranged in front of a light source or reflector. Each pixel comprises a column of liquid crystal molecules suspended between transparent electrodes, accompanied by two polarizing filters with perpendicular axes of polarity. The Liquid Crystal Display module is widely employed in microcontroller devices for visual output purposes (Liquid Crystal Display, 2010). The proposed system incorporates a 20x4 LCD module as its display device, capable of

Recent Trend in Civil Engineering and Built Environment Vol. 6 No. 1 (2025) p. 174-185

presenting twenty characters in one row and a total of eighty characters in a single display. This LCD employs HDD44780 parallel interfacing, a specialized controller designed for the exhibition of monochrome text displays.

2.3 Selection of Software

The chosen software is the Blynk IoT platform and Arduino IDE to run the design the interface of IoT interface and run the coding and upload the coding into the microcontroller.

2.3.1 Blynk Apps

Blynk is a specialized software featured in serving as an IoT platform compatible with IOS and Android smartphones. Its primary purpose is to enable remote control of Arduino, Raspberry Pi, and NodeMCU devices over the Internet. The application facilitates the creation of graphical interfaces or human-machine interfaces (HMIs) by compiling and assigning appropriate addresses to various widgets. Essentially designed for the Internet of Things, Blynk empowers users to remotely manage hardware, display sensor data, store and visualize information, and perform various other functionalities (Blynk, 2024).

2.3.2 Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application that connects to the Arduino Board and is created in the computer language C or C++ (Arduino IDE, 2024). The programming language will be compiled and the software will be utilized to programs this proposed system. It may upload to the Arduino Board from the compiled language, and the Arduino will work according to the code. Not only that, the Arduino IDE software includes a tool called Serial Monitor that may be used to 18 troubleshoot the program's written sketches or programs.

3 Methodology

3.1 Method of Study

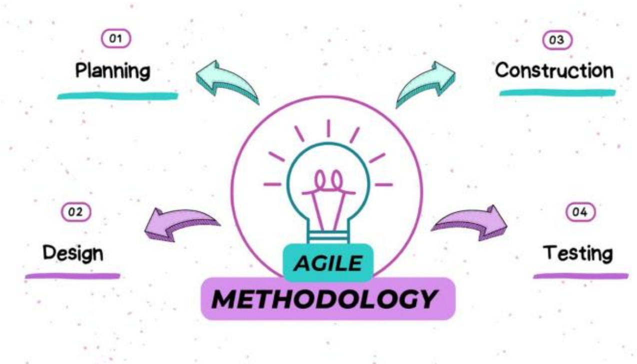


Figure 3.*1* *Illustration of The Agile Methodology*

A suitable methodology is required to be chosen for carrying out the study successfully. It is essential in organizing the tasks in order to efficiently achieve the study objectives and is a group of systemized applications and procedures (Michael, 2017). In developing the proposed system for detecting and measuring level and turbidity in water tank, this study applied the Agile methodology.

The Agile methodology is a group of repetitive and progressive procedures implemented in a project (Monday Project(n.d),2020). The Agile methodology was selected because of its iterative feature that allow improvements and changes to be made to the system for better adaptability. This methodology is also user-centered where it highly focuses on what the users want and need. It also ensures maximum quality and satisfaction of the system in the end.

The Agile methodology consists of few types of phases which are the planning, design, construction, implementation and testing phase. The Agile methodology further consists of sprints which are the iterations present in the model. The tasks are divided into sprints while carrying out the project. Figure 3.1 shows the illustration of the Agile methodology that was used in the project planning for the proposed system.

Figure 3.2 shows the process taken in completing the project of water tank level and turbidity detection and monitoring system, which cover literature review, development of software and hardware, testing, and report writing.

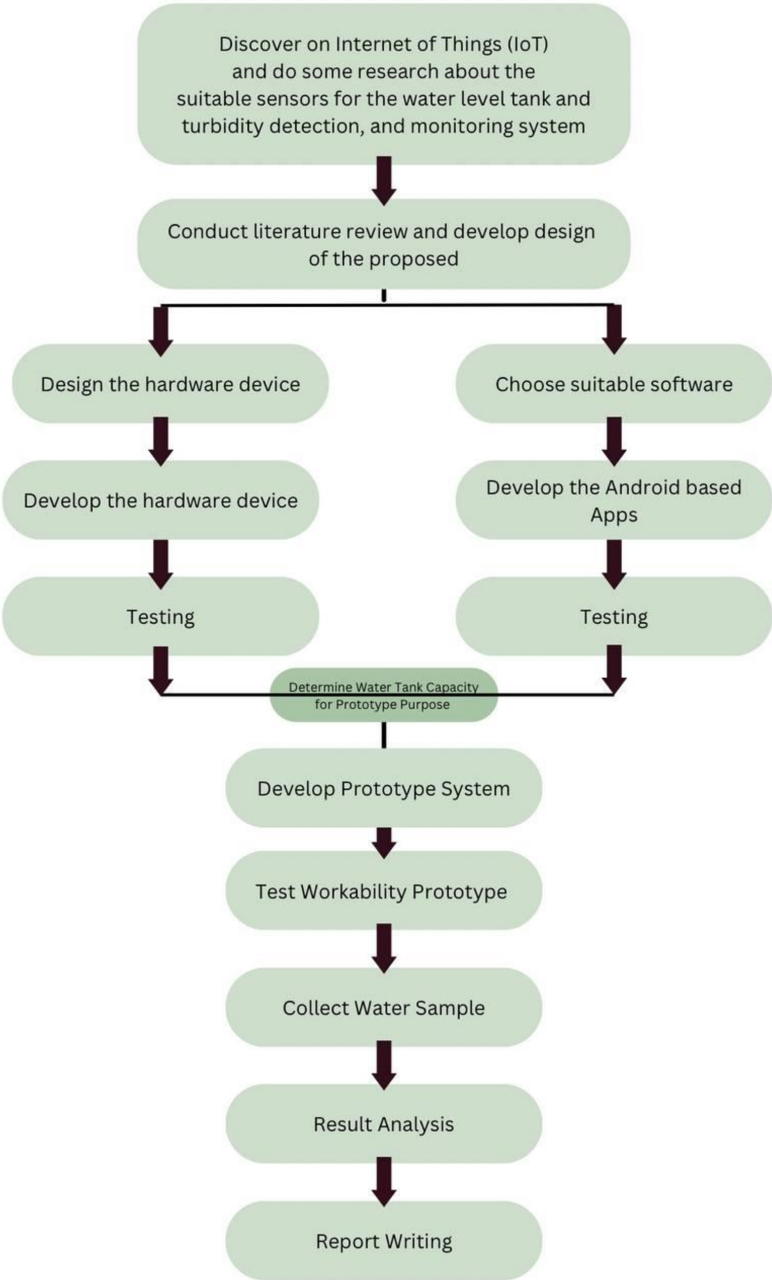
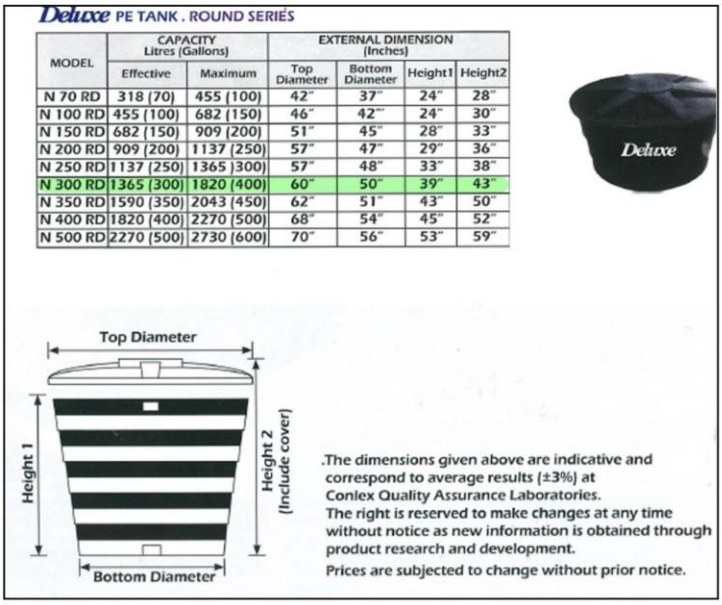


Figure 3.2 *Flow of study in developing the IoT based system for detecting and monitoring of water tank level and turbidity in residential building*

3.2 Water Level Tank

Polyethylene tanks in Figure 3.3 are a dependable choice for residential water storage, offering durability and affordability. Constructed from high-density polyethylene, they resist corrosion and withstand diverse weather conditions, ensuring long-term reliability. With standardized dimensions, these tanks are easily installed in residential areas, maximizing space utilization (Deluxe, 2023). Equipped with secure lids and fittings, these tanks play a vital role in efficient water management for households, addressing issues of water scarcity or irregular supply.


Deluxe PE TANK . ROUND SERIES

MODEL	CAPACITY Litres (Gallons)		EXTERNAL DIMENSION (Inches)			
	Effective	Maximum	Top Diameter	Bottom Diameter	Height1	Height2
N 70 RD	318 (70)	455 (100)	42"	37"	24"	28"
N 100 RD	455 (100)	682 (150)	46"	42"'	24"	30"
N 150 RD	682 (150)	909 (200)	51"	45"	28"	33"
N 200 RD	909 (200)	1137 (250)	57"	47"	29"	36"
N 250 RD	1137 (250)	1365)300)	57"	48"	33"	38"
N 300 RD	1365 (300)	1820 (400)	60"	50"	39"	43"
N 350 RD	1590 (350)	2043 (450)	62"	51"	43"	50"
N 400 RD	1820 (400)	2270 (500)	68"	54"	45"	52"
N 500 RD	2270 (500)	2730 (600)	70"	56"	53"	59"

Figure 3.*3* *PE Tank Size (Deluxe,2023)*

3.2 Water Demand Capacity

Determining the suitable size and capacity of water tanks in Figure 3.4 for effective supply management hinges on understanding and accurately estimating the daily water demand of consumers. This demand encompasses various activities like drinking, sanitation, and domestic needs. It is crucial for designing an efficient water supply system capable of meeting the population's daily requirements. By analyzing data from a table displaying daily water demand, planners can identify peak demand periods. This insight allows for appropriately dimensioning water storage infrastructure, ensuring a reliable and sustainable water supply to meet the community's needs.

Table B.1 : Tabulation of Estimated Water Demand Rate for Planning of External Water Reticulation System

Type of Premises/Buildings	Average Daily Water Demand (Litres)
Low cost terrace house / low cost flat	1100 / unit
Single storey terrace house / low cost house (less than RM25,000) / low medium & medium cost flats	1300 / unit
Double storey terrace house / high cost flat / apartment / town house	1500 / unit
Semi detached house / cluster	2000 / unit
Bungalow / condominium	2000 / unit
Wet market	1500 / stall
Dry market	450 / stall

Figure 3.4 *Average Water Demand for Consumer*

3.3 Water Tank Ratio

This project centers around the development of a water tank monitoring system, employing a ratio between an actual-size tank in Figure 3.3, modeled after the N300 with a height of 39 inches (99.06cm) and a consumer capacity of 300 to 400 gallons, and a scaled-down prototype tank measuring approximately 20 cm in Figure 3.5. The system incorporates three notification thresholds, high (90%), medium (50%), and low (30%) levels it will communicated through Blynk apps and an LCD display. These notifications offer real-time updates on water levels, facilitating efficient management and monitoring of water resources by users. Table 3.1 provides a ratio comparison between the actual water tank and the prototype tank (Deluxe, 2023).

Figure 3.5 *Prototype Water Tank*

Table 3.1 *Water Level Ratio*

WATER LEVEL	Actual Size Tank (99.06cm)	Prototype Tank (20.00cm)
High (90%)	= 90% x 99.06cm = 89.16cm	= 90% x 20.00cm = 18.00cm
Medium (50%)	= 50% x 99.06cm = 49.53cm	= 50% x 20.00cm =10.00cm
Low (30%)	= 30% x 99.06cm = 29.72cm	=30% x 20.00cm = 6.00cm

3.4 Turbidity

Turbidity serves as a gauge for the relative clarity of a liquid, particularly water, functioning as an optical characteristic. This measurement assesses the extent of light scattering when light passes through a water sample, with higher intensity indicating greater turbidity. Various materials contribute to turbidity, such as clay, silt, organic and inorganic matter, algae, colored compounds, and microscopic organisms (USGS science for a changing world, 2018). A turbidity meter quantifies the amount of suspended particulate matter in water, and elevated turbidity levels can impact water temperature and dissolved oxygen. High turbidity results in a cloudy appearance, as suspended particles absorb more solar radiation heat than water molecules, transferring it to the surrounding water through conduction. Turbidity is a key parameter in water quality standards, indirectly reflecting the presence of particles and influencing public acceptance of alternative water sources due to the association of germs with suspended particles (Silva Vieira et al., 2013). Figure 3.6 illustrates the acceptable turbidity range in NTU, providing an indication of water clarity, ranging from clear to dirty water (Emma Atkin, 2020).

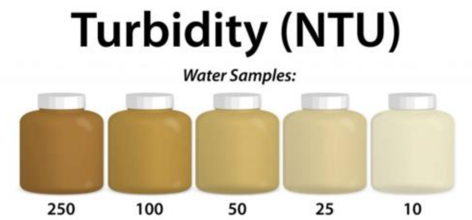


Figure 3.6 *NTU Turbidity Range (Emma Atkin, 2020)*

3.5 Water Quality Index

The Water Quality Index (WQI) in Table 3.2 serves as a numerical tool that consolidates various water quality parameters into a single value, offering a comprehensive assessment of water quality. By considering physicochemical, biological, and sometimes microbiological factors, it provides a holistic overview. Widely employed to assess water suitability for purposes like drinking and recreation, the WQI facilitates effective communication to both the public and policymakers. Notably, research articles and journals, exemplified by the works of Brown et al. (2010) and Smith et al. (2015), extensively delve into the development, application, and refinement of water quality indices, emphasizing their pivotal role in water management and conservation.

Table 3.2 *Water Quality Index*

Water Quality Index Level	Water Quality Status (WQS)	Water Quality Grading	Possible uses
0-25	Excellent	A	Drinking, irrigation and industrial purpose
26-50	Good	B	Drinking, irrigation and industrial purpose
51-75	Poor	C	Irrigation and industrial purpose
76-100	Very Poor	D	For irrigation purpose
>100	Unsuitable for Drinking and fish culture	E	Proper treatment required for any kind of usage

3.6 Turbidity Ratio

This project aims to create a water turbidity monitoring system utilizing a ratio between an actual turbidity range and a scaled-down prototype range. The actual turbidity levels range from 10 NTU (clear water) to 250 NTU (hazardous). Utilizing the water quality index (WQI), the system establishes a correlation between turbidity levels and water quality status, spanning from excellent for drinking and fish culture to unsuitable. The implementation includes three notification thresholds, clear water (20%), dirty water (50%), and very dirty water (30%) which are communicated through Blynk apps and an LCD display. These real-time notifications provide insights into water quality, enabling timely responses for the maintenance of safe and suitable conditions as Table 3.3.

Table 3.3 *Turbidity Ratio*

TURBIDITY	NTU	WQI
Clear (20%)	10NTU – 25NTU	Grade : A Status : Excellent
Dirty (50%)	50NTU	Grade : B/C Status : Good/Poor
Very Dirty (90%)	100NTU – 250NTU	Grade : D/E Status : Unsuitable

4 Result and Analysis

4.1 Prototype of IoT Water Level and Turbidity in Tank

The prototype employs Internet of Things (IoT) technology to monitor both water level and turbidity in a tank. Arranged in Figure 4.1, the system is centered around a Durian Uno microcontroller, linked to an ultrasonic sensor for precise water level measurement and a turbidity sensor for water clarity assessment. Real-time data visualization is facilitated through a Liquid Crystal Display (LCD). The ultrasonic sensor accurately gauges the distance to the water surface, providing precise level information, while the turbidity sensor evaluates water quality by measuring particle concentration. The prototype, as depicted in Figure 4.2, features a simulated water tank and three turbidity samples for testing purposes. Tailored for tank houses, this system serves as a comprehensive solution for remotely monitoring water conditions. The inclusion of a prototype water tank and turbidity samples enhances the project's practicality, allowing for realistic testing and validation of the IoT-based technology in authentic scenarios.

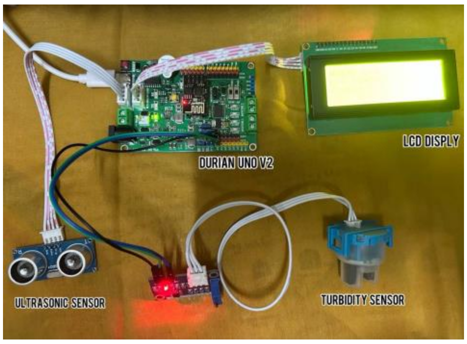


Figure 4.1 *Prototype of Water Tank Level and Turbidity Detection and Monitoring System*

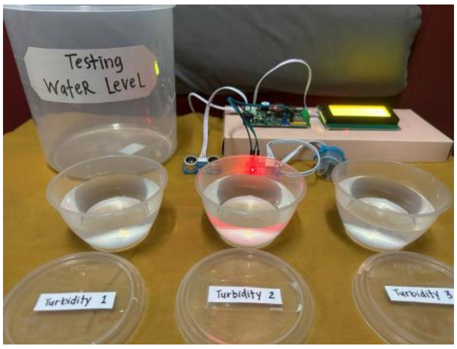


Figure 4.2 *Apparatus*

4.2 Sample Location

To evaluate the system's performance, a thorough testing strategy has been implemented across three distinct locations in Parit Raja, Johor, as depicted in Figure 4.3, Taman Universiti, Taman Persona, and Taman Wira Jaya. The testing procedure involves the collection of three samples at each location, with each sample obtained at different times to encompass a comprehensive representation of environmental conditions. Following data collection, the analysis is conducted by calculating the average of the three samples for each specific location. This method ensures a robust evaluation of the project's effectiveness in diverse settings, providing a reliable overview of its performance and enabling the identification of potential variations in results across the sampled areas.

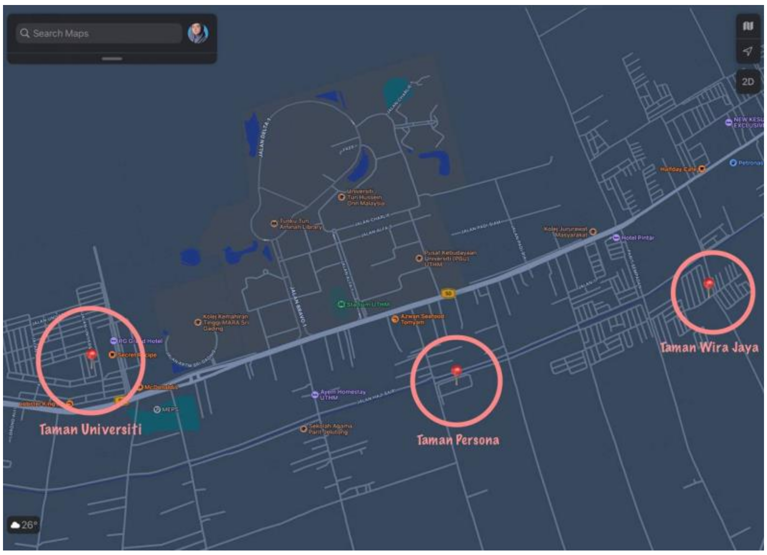


Figure 4.3 *Location of Sample Testing*

4.3 Water Level Result

In the water level testing, Figure 4.4 showcases three experiments, each reflected on the LCD display with varying water levels represented as percentages. The initial test displayed a 45% water level, indicating a low level, while the second test recorded an 80% water level, signifying a medium level in the tank. The final test indicated a 95% water level, suggesting a full tank. These results offer a comprehensive insight into the water levels within the tank across different conditions. Furthermore, Table 4.1 below presents the ratio of water levels in centimeters between the prototype (20 cm) and the actual tank size (99.06 cm). This ratio serves as a valuable reference for estimating water levels in the tank house, allowing for a practical approximation based on the prototype's measurements and contributing to effective water management.

Figure 4.4 *LCD Display Result Water Level*

Table 4.1 *Result Water Level*

WATER LEVEL	Prototype Tank (20.00cm)	Actual Size Tank (99.06cm)
High (90%)	**= 95% x 20.00cm = 19.00cm**	= 95% x 99.06cm = 94.12cm
Medium (50%)	**= 80% x 20.00cm =16.00cm**	= 80% x 99.06cm = 79.25cm
Low (30%)	**=45% x 20.00cm = 9.00cm**	= 45% x 99.06cm = 44.58cm

4.4 Turbidity Result

This study aimed to evaluate turbidity levels in water samples collected from the three distinct locations. To ensure a comprehensive analysis, three samples were collected at each location, and their turbidity levels were measured using standardized methods. The LCD display results in Figure 4.5 and corresponding values in Table 4.2 showcase average turbidity values obtained from each location. The displayed results reveal a consistent range of 9% to 11% turbidity across all three locations. Converting these percentages to Nephelometric Turbidity Units (NTU) yields a range of 10 NTU to 25 NTU, aligning with widely accepted standards for excellent water quality. The consistent grade A classification in Table 3.3 further reinforces the superior water quality in these areas. In conclusion, the study underscores the importance of on going monitoring to ensure the sustained safety and quality of water supply in Taman Pesona, Taman Wira Jaya, and Taman Universiti.

Figure 4.5 *LCD Display Result Turbidity of Three Location*

Table 4.2 *Result Testing at Parit Raja, Johor*

Result	Taman Pesona	Taman Wira Jaya	Taman Universiti
Sample 1	11%	14%	9%
Sample 2	10%	15%	9%
Sample 3	11%	15%	9%
Average	**11%**	**15%**	**9%**
Turbidity	**Clear (20%)**	**Clear (20%)**	**Clear (20%)**
NTU	**10NTU – 25NTU**	**10NTU – 25NTU**	**10NTU – 25NTU**
WQI	**Grade : A Status : Excellent**	**Grade : A Status : Excellent**	**Grade : A Status : Excellent**
Result Sample	**The result of the samples show that the water in each sample CLEAR**		

4.5 Result of Iot Blynk Apps

The IoT-based Water Level and Turbidity project employs Blynk, a mobile application tailored for IoT projects, to showcase real-time information on water level and turbidity in a tank. Utilizing a user-friendly interface, the Blynk app enables consumers to monitor their tank's status by displaying details like water level and turbidity readings on a virtual LCD display within the app. Accessible on mobile devices, this interface facilitates convenient monitoring of water conditions. The project also features a notification system that promptly alerts consumers to any changes in water level or turbidity, enhancing the system's proactive monitoring capabilities. Through the Blynk app, users can access comprehensive project results, including data from various samples, offering a detailed overview of water quality in their tank houses.

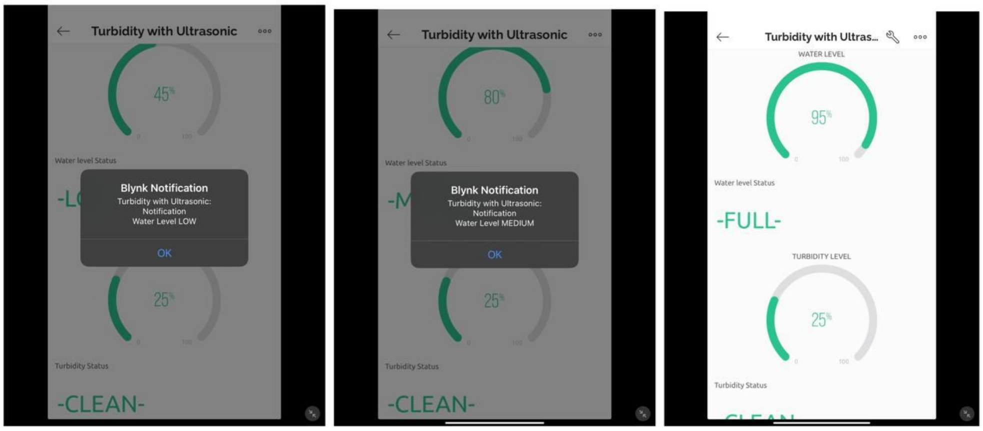


Figure 4.5 *Water Level Result*

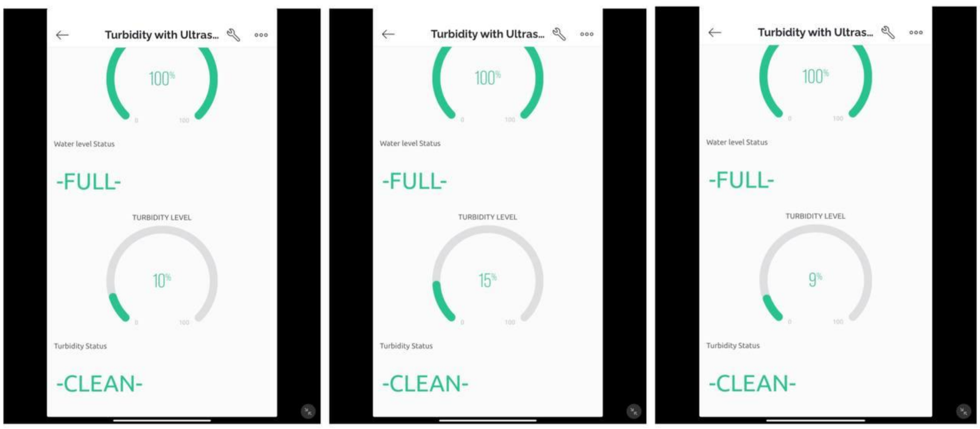


Figure 4.6 *Average Turbidity Result of Three Location*

5 Conclusion

In conclusion, the IoT-based water level and turbidity detection and monitoring system presented in this project have not only met but surpassed its primary objectives, achieving significant milestones in advancing water management and quality monitoring. The primary goal of designing an IoT-based system for water level and turbidity detection in residential building tanks has been meticulously realized. The system's architecture incorporates cutting-edge sensor technologies and communication protocols, ensuring precise and real-time data collection. The thoughtful integration of IoT principles facilitates seamless connectivity, allowing users to access critical information remotely.

Additionally, the prototype's inclusion of both water level and turbidity detection components offers a comprehensive monitoring solution adaptable to various settings, from residential homes to larger civil engineering projects. Usability is a crucial aspect of technological innovation, and in this regard, the water level and turbidity detection and monitoring system stands as a testament to user-centric design. Through extensive testing and user feedback, the system has proven its practicality and effectiveness, with an intuitive interface, timely alerts, and historical data empowering both civil engineers and consumers with invaluable insights into their water storage systems.

As we conclusion, the implications of this IoT-based system are profound. For civil engineers, the ability to remotely monitor water levels and turbidity in residential building tanks offers a proactive approach to water resource management, preventing potential crises and contributing to efficient infrastructure planning. For consumers, the system provides peace of mind by ensuring constant awareness of their water supply conditions, allowing them to access real-time data and take prompt actions in response to any anomalies detected. The successful achievement of the three main objectives, namely designing the IoT-based system, producing a prototype, and testing workability of the system, reflects the transformative potential of IoT in enhancing the quality and reliability of essential services. This study not only fulfills its intended purposes but also sets the stage for a more resilient and informed approach to water management, promising a sustainable and connected future across both civil engineering practices and everyday consumer experiences.

Acknowledgement

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