Developing A Water Management System

A Report Submitted

For **B.Tech. Project Part II (CE852)**

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FORWARD

I hereby forward the ***Report*** *entitled "****Developing A Water Management System"*** *prepared by* **SACHINDRA RAI** and **RUDRASHIS GORAI** *in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in* **Department of Civil Engineering** *from Indian Institute of Engineering Science and Technology, Shibpur is an authentic work under my supervision and guidance.*

……………………………….

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Table of Contents

Part I: An overview on Green Building

Part II: Developing A Water Management System

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Part- I

An overview on Green Building

Green Building & it's History

The structures in which we live, work, and play shield us from the harsh elements of nature, but they also have a wide range of effects on our health and the environment. As the impact of buildings on the environment becomes more obvious, a new idea known as "green building" is gaining traction[1].

Green building is the discipline of designing structures and employing procedures that are ecologically responsible and resource-efficient, throughout the building's lifecycle, from site selection to design, construction, operation, maintenance, renovation, and deconstruction. The traditional architectural design objectives of economy, usability, durability, and comfort are complemented by this method. These kinds of buildings are also known as sustainable or high-performance buildings[2].

The world is moving closer to a global agenda anchored by the Sustainable Development Goals (SDGs) initiatives. These objectives indicate a long-term development strategy, which has culminated in the notion of green buildings, which has become a new trend in the built environment's innovative technology field. Many developed and developing countries have established goals and strategies for prioritising planning and actions to exploit green building opportunities. To achieve sustainable development, the notion of green buildings has grown in a remarkable way[3]. Furthermore, green buildings have a lot of potential for diversifying built environment initiatives in numerous aspects of social, economic, and environmental development[4]. The concept of green building is more appealing because of its additional benefits and incentives, which together provide a brighter future for the construction industry and, indirectly, a better world to live in[5]. Furthermore, green buildings are not only built to conserve energy and resources, but they also use recycled materials and emit less hazardous compounds throughout the course of their lives[6].

As a whole, the green building movement is intrinsically linked to the sustainability movement; however, despite their popularity, the two terms are not really well understood. Sustainability goes counter to the drive to hyper optimise design and processes for a small set of variables. Rather, it is based upon a holistic evaluation of the system and the world as whole, and minimises the impact of the activity on the world at large[7].

Contrary to popular perception, this is not a novel concept. A lot of the core ideas of green buildings date back millenia. Most native cultures used locally sourced material to build their houses. Houses and communities were structured in order to best utilise natural heat and light. The modern Western green building movement started in the 1960's, precipitated by the twin peaks of the environmental movement and the energy crisis. Today, green buildings are a standard and popular part of the architecture and design world, and a common customer demand[8].

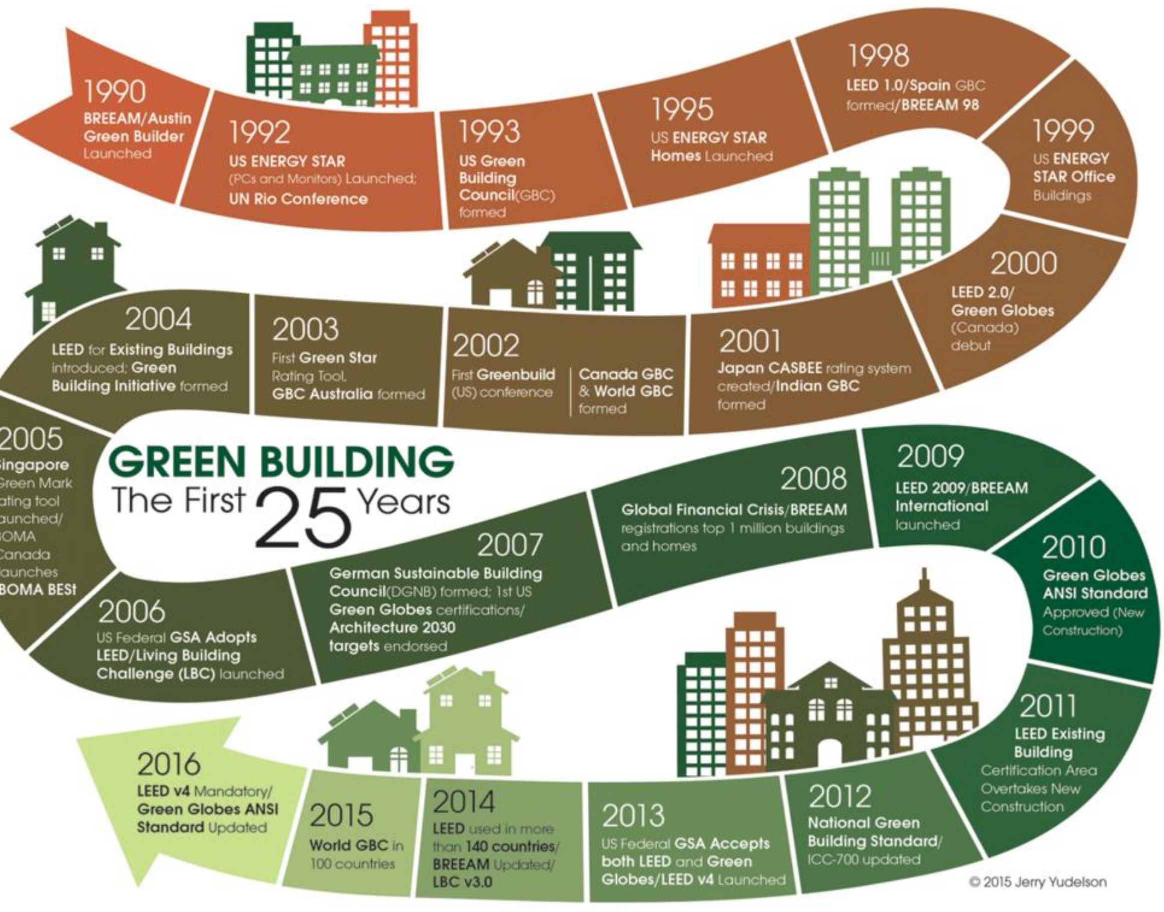

Figure 1. Schematic Representation of the first 25 years of Green Building (© Jerry Yudelson[9])

Objectives of Green Building

A green building is one that is ecologically friendly and efficient in its use of resources throughout its lifespan. These goals go above and beyond the traditional considerations of economy, usability, durability, and comfort in building design.

Green buildings are intended to lessen the built environment's total impact on human health and the environment by:

- Using energy, water, and other resources efficiently
- Increasing staff productivity while protecting occupant health
- Reducing waste, pollution, and degradation of the environment

Green buildings, for example, may employ sustainable materials in their construction (e.g., reused, recycled-content, or renewable resources); provide healthy indoor environments with low pollutants (e.g., reduced product emissions); and/or have water-saving landscaping (e.g., by using native plants that survive without extra watering)[10].

Components of Green Building

- **Energy Efficiency and Renewable Energy**

  Energy efficiency is defined as the reduction of the quantity of energy used to provide the same or better quality of service to the consumer in a cost-effective manner. Resource and technology standards, rules, and incentives are examples of common policies that can help to accelerate the adoption of energy-efficient technologies and practices in all sectors of the economy.

  Renewable energy is energy that is produced in part or totally from non-depleting energy sources for direct use or power generation. Wind, solar, and geothermal energy are commonly included in renewable energy definitions. Low-impact or tiny hydro, biomass, biogas, and waste-to-energy are also frequently considered renewable energy sources[11].

- **Water Efficiency**

  In the near future, water efficiency and conservation will become a critical element in green construction. According to the UNEP, buildings consume 20% of the world's available water and water resources become scarcer each year. Water efficiency means using improved technologies and practices that deliver equal or better service with less water. Improving water efficiency lowers operating expenses (such as pumping and treatment) and minimises the demand for new supplies and infrastructure expansion. It also minimises withdrawals from limited freshwater supplies, allowing more water to be used in the future while simultaneously enhancing water quality and aquatic habitat[12].

- **Environmentally Preferable Building Materials and Waste Reduction**

  Building materials and components are frequently discarded throughout the construction or demolition process, with construction debris accounting for 28 percent of landfill garbage in the United States. Setting criteria for evaluating building materials is the first step in determining environmentally appropriate construction materials. The material criteria may differ per project, with a focus on reducing the possible impact on the environment.

  In addition, waste management has become one of the major environmental problems in many countries. Significant amounts of construction material end up being discarded as waste, increasing both consumption of resources and pollution[13].

- **Indoor Air Quality**

  Indoor air quality problems are not limited to homes. Many office buildings have significant air pollution sources. Several buildings suffer from inadequate ventilation. For example, mechanical ventilation systems may not be designed or operated to provide adequate amounts of outdoor air. Some typical problematic volatile compounds released from building materials include formaldehyde, acetaldehyde, toluene, isocyanates, xylene, and benzene. Ventilation and climate control are two of the most essential indoor air quality (IAQ) control strategies. Most experts believe that ventilation is an important part of IAQ regulation[14].

- **Smart Growth**

  Smart growth is an urban planning and transportation concept that concentrates growth in compact walkable urban centers to avoid sprawl. Communities are reinvesting in existing infrastructure and reclaiming historic structures, maintaining natural lands and vital environmental regions, safeguarding water and air quality, and repurposing already built land. Communities are limiting the usage of private transport for daily tasks by creating neighbourhoods where most required amenities are close to houses. These neighbourhoods thrive as places to live, work, and play. These cities' high quality of life boosts their economic competitiveness, expands commercial prospects, and boosts the local tax base[15].

- **Thermal comfort**

  Thermal comfort, a complex dynamic of temperature and humidity, is intimately related to building user pleasure. Researchers have focused a lot of work on modelling and assessing the thermal comfort level in green buildings vs conventional ones. As a result, a temperature range for the desired room might be proposed. Psychological, physiological, cultural, and behavioural factors may all contribute to the degree of adaptive thermal comfort[16].

Green Building Rating Systems

A number green rating systems have been created around the world to assess the long-term viability of construction projects. Their categories and criteria have been updated on a regular basis to keep up with the building construction trend.

LEED i.e. Leadership in Energy and Environmental Design, BREEAM i.e. Building Research Establishment Assessment Method, i.e. CASBEE Comprehensive Assessment System for Building Environmental Efficiency and Green Star NZ are some of the most important green rating systems.

BREEAM is seen as the first green building rating assessment in the world, launched and operated by BRE (Building Research Establishment) in the UK[17]. It was introduced to the market in 1990 and was first revised to assess offices in 1993. It is widely accepted that almost all later major green rating systems such as LEED, Green Star, and CASBEE are under the influence of BREEAM (Figure 2). It is still widely used owing to its flexibility. It not only assesses local codes and conditions but also allows application in international buildings[18].

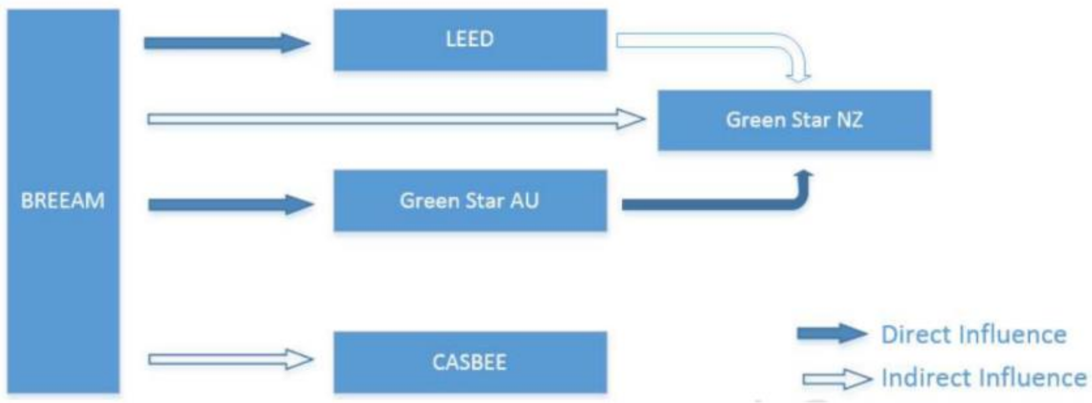

Figure 2. The relationship among green ratings (adapted from Mao[19])

LEED is a voluntary standard developed by USGBC (US Green Building Council)[20-21]. It was first launched in 1998 with a pilot version (LEED 1.0)[22-23]. Despite the fact that it was published after BREEAM, it is the most frequently used rating scheme in terms of countries, with over 79,000 projects[24-25] in 135 countries in 2012, and over 160 countries and territories now[26].

CASBEE was developed by the collaboration of academia, industry, and the local governments in 2001 in Japan. Owing to its limitation to the Japanese context, the number of certified buildings is still modest. However, it is the rating which evaluates the broadest context and started releasing a pilot version for worldwide use in 2015. CASBEE could assess the buildings starting from the design to the renovation with criteria from CASBEE Buildings, CASBEE for Commercial Interiors, and CASBEE for Temporary Construction manuals, while CASBEE for Urban Development and CASBEE for Cities manuals are used as frameworks to evaluate a group of buildings[27-28].

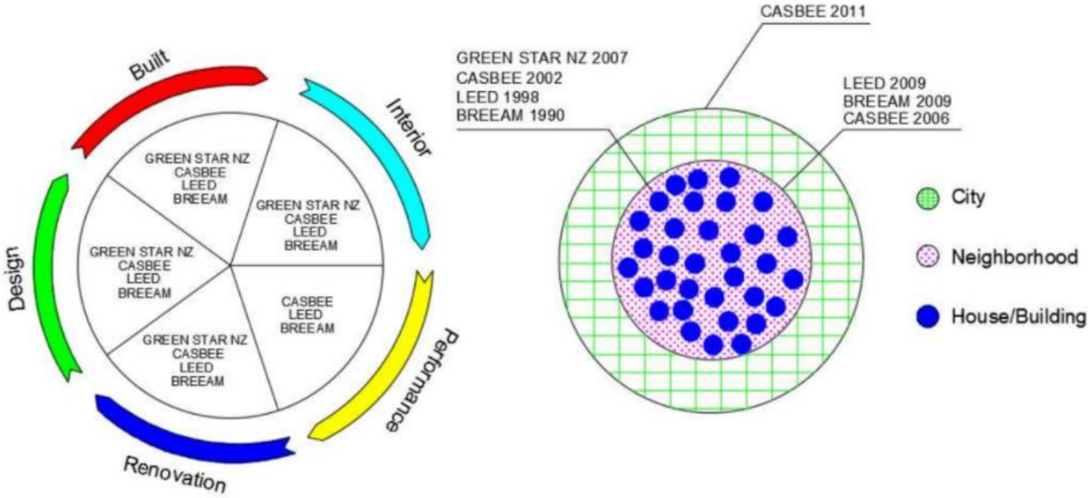

Figure 3. Overview of Green Building Rating Tools [29]

Green Building Rating Systems for India

GRIHA is an acronym for Green Rating for Integrated Habitat Assessment. GRIHA is a rating system that allows individuals to compare their building's performance to nationally accepted benchmarks. It assesses a building's environmental performance throughout the course of its full life cycle, establishing a clear definition of what constitutes a 'green building.' Based on acknowledged energy and environmental principles, the grading system aims to achieve a balance between known practises and new national and international concepts.

Figure 4. Evolving landscape of sustainable habitats in India: genesis of GRIHA (© griha.org)

The system was created to aid in the 'design and evaluation' of new structures (buildings that are still at the inception stages). A structure is evaluated based on its expected performance throughout its full life cycle, from conception to operation. The following stages of the life cycle have been highlighted for assessment:

- Pre-construction stage: (intra- and inter-site issues like proximity to public transport, type of soil, kind of land, where the property is located, the flora and fauna on the land before construction activity starts, the natural landscape and land features).
- Building planning and construction stages: (Resource conservation and demand reduction, resource usage efficiency, resource recovery and reuse, and occupant health and well-being requirements). Land, water, energy, air, and green cover are the primary resources discussed in this section.
- Building operation and maintenance stage: (These include challenges such as building system and process operation and maintenance, energy consumption monitoring and

recording, and occupant health and well-being, as well as global and local environmental issues.)[30]

Evolution of Green Building

Evolution of green building from sustainable development has been a strenuous process for achieving sustainable development through its emergence in various areas. Green buildings play a vital role in the infrastructure development of countries and regions with a focus on the sustainable management of buildings from the design and construction to operation & maintenance stages. The overall aim is to reduce resource degradation, impacts on climate and the emissions associated with buildings. To measure the performance of green buildings, various tools have been developed known as green building rating tools. These tools assess green buildings from cradle to grave. After assessment, buildings are certified as green buildings that show sustainable construction with a better quality of life. Reviewing various literature that addresses the benefits of the green building demonstrated conclusively that green buildings provide higher benefits than the conventional (non-green) buildings in all performance areas. When it comes to the subject of whether green construction prices are greater or lower than conventional buildings, most empirical research has found that green building costs are higher, ranging from -0.4 percent to 21%[31]. Because green building necessitates the use of many green technologies not found in conventional structures, cost increases are possible. Despite the fact that the research supported the thesis that green buildings emerged from sustainable development, there is still a lack of acceptance in various countries, particularly in poor countries. Many countries, however, are deficient in terms of green certified buildings and the use of green building rating methods that rigorously score green structures from design to demolition in order to obtain certification. Various studies have revealed that green building adoption is slow when there are no green building grading systems available, owing to the greater initial expenses involved with green structures[32]. Green building rating techniques could be combined with life cycle costing to detect various costs connected with green buildings, such as energy efficient technology, sensor technology, and a variety of other new green technologies. However, to provide the construction sector with new tools for the next level of web-based automation and cost computation, this gap must be closed. This will pique the interest of investors and developers, as well as buyers, in the long run[33].

IoT: A Brief

The Internet of Things (IoT) is a term that refers to the network of devices that connect to the internet. These are typically low-powered computing resources that communicate in a network (i.e. : Internet). Fundamentally, the Internet of Things aims to automate ordinary living and provide simplicity, comfort, and efficiency by digitally representing everyday objects. Although the Internet connects technically computers and smartphones, it is more concerned with connecting people than with connecting objects. Almost often, some form of human connection is required. IoT, on the other hand, is more about data that devices automatically share between themselves with little or no human input. Intelligent data analysis systems can not only automate operations using "if-then" logic, but also optimise processes and take appropriate actions (for example, determining the optimal driving route to work based on current traffic)[34].

Machine Learning: A Brief

Machine-learning algorithms statistically seek patterns in massive amounts of data. And when we talk about data, we're talking about a wide range of things: numbers, words, photos, and so on. Any entity that can be stored in a digital form is fair game for a machine-learning algorithm[35].

Data Analytics: A Brief

Data analytics is the science of combining heterogeneous data from various sources, making inferences, and making predictions in order to enable innovation, obtain a competitive corporate edge, and assist strategic decision-making. Online analytical processing (OLAP), data mining, visual analytics, big data analytics, and cognitive analytics are all terms that have been used to describe data analytics. Any data-driven decision-making is also referred to as analytics[36].

Cloud Platforms: A Brief

A cloud is simply a remote system that hosts a web service that you may use through a user interface. Anything that includes offering hosted services via the internet is referred to as cloud computing. Infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) are the three primary kinds of these services.

There can be a lot going on in the cloud, and depending on what has to be done, the proper technology is picked. Python's exceptional arsenal of libraries dedicated to statistics, AI, and machine learning would be the ideal choice here if data analysis or any type of artificial intelligence over collected data is required. To summarise, there are many technologies that are appropriate for the cloud, but ultimately, what is picked is determined by the task at hand. Two or more technologies are frequently used simultaneously in the cloud[37].

Building Analytics

An open-ended building management system enables facility managers to diagnose and identify potential energy waste, potentially uncomfortable situations for building occupants, and maintenance difficulties using enormous amounts of data and statistics. Facility managers and administrators can examine the data they need from behind a desk or on the go thanks to dynamic user interfaces and mobile apps.

Building management applications and programmes collect a great quantity of data, and evaluating and transforming that data into information can be a key decision-making tool in the industry. It can help quickly discover and fix maintenance, comfort, and energy concerns in the building, resulting in increased energy efficiency and cost savings.

Many utilities are experimenting with consumer communication strategies that can genuinely affect their decisions and have a long-term impact. These include measures for assisting customers in comparing their energy use to that of their peers and neighbours, as well as notifications that alert customers to abnormalities that may need to be addressed. Modern communications and big-data analytics tools can tailor communication so that clear and reliable information is sent when it is most needed. Savings of at least 3% per year and a 5 percent reduction in peak demand look to be feasible.

A building-analytics strategy includes automated fault identification and diagnostics for anticipating energy and cost savings. Building analytics evaluate a building's data every few minutes, eliminating the need for periodic audits to track performance, comfort levels, and energy and maintenance data. This data allows for preventive building repair while maintaining energy efficiency. It can also assist a novice or young facility manager in learning the finest facility maintenance procedures.

Consider the following scenarios in which building analytics services could help a college or institution save money on energy:

Room Occupancy Optimization: When evaluating heating and cooling demands, temperature set points that do not take building occupancy into account waste a lot of energy. Giving the HVAC a break when no one is in the room may seem straightforward, but it may be difficult in huge buildings with hundreds of rooms. Building analytics enable facility managers to spot waste so that temperatures can be altered to reduce energy use and, in turn, save money[38-39].

Prevent Simultaneous Heating and Cooling: Leaks in an air-handling unit can be detected using building analytics. During the heating season, for example, a leaking cooling valve might cost thousands of dollars per week due to the simultaneous heating and cooling of air provided to the campus. These inefficiencies go undiscovered without establishing analytics, and the institution wastes money that could be spent on other services to improve the learning environment.

Catch Up on Deferred Maintenance: While structures age, schools are notorious for postponing costly repair improvements due to economic constraints. Building analytics assist facility managers in identifying and prioritising initiatives that will provide the greatest return on investment. Schools can catch up on delayed maintenance projects even faster when energy savings are channelled into further cost-saving measures[40].

Measure Energy Consumption of the Residents: Consumers and users can be informed about their energy usage in a variety of ways. Inhabitants of a building can utilise building analytics to learn about their energy usage, which can lead to a more mindful approach to energy use among residents.

Proposed Ideas & Expected Outcomes

We wish to work on a project in which we can use some trending technologies in the field of Building Management Systems such as IoT for seamless integration and processing, attribution of energy usage to human activities, big data analytics for insightful analysis, renewable energy and storage for increasing the flow of green energy. For this purpose, we have thought of the following ideas:

- Design an IoT-based Building Management Cloud Platform for IIEST Shibpur

  The goal is to develop a building management cloud Platform for IIEST Shibpurby using the technologies of cloud computing and Internet of things. The cloud servers would provide data storage, computing and hosting abilities whereas the software would be able to take the responsibility for visualization interfaces and modularization services. If there already exists a building management system for IIETS, we can try to expand its capabilities such as monitoring, controlling, data processing, management and services customization and try to integrate in the building management cloud platform[41].

❖ Applying machine learning to accurate estimation of heating and cooling load for an HVAC system

Heating, ventilation, and air conditioning consumes 35% of total building energy which is highest among all sources. Understanding the patterns in heating and cooling load for an HVAC system can provide a better understanding of the energy uses by HVAC in a certain climate[42].

❖ Development of a low-cost IoT Based Water Management System for a residential building at IIEST Shibpur

Using flow sensors and the abilities offered by cloud platforms, we can try to develop a low-cost IoT based water management system for a residential building at IIEST Shibpur which may be installed to measure the amount of water supplied to a particular building and the data can be used to effectively aware the residents of the building about their water usage and conservation as well as it may help to detect anomalies which may help to avoid loss of water due to late maintenance issues[43].

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Part- II

Developing A Water Management System

Abstract

Wireless communication developments are creating new sensor capabilities. The current developments in the field of sensor networks are critical for environmental applications. Internet of Things (IoT) allows connections among various devices with the ability to exchange and gather data. IoT also extends its capability to environmental issues in addition to automation industry by using industry 4.0. As water is one of the basic needs of human survival, it is required to incorporate some mechanism to monitor water quality time to time.

Alongside, water scarcity is a huge problem as four billion people — almost two thirds of the world's population — experience severe water scarcity for at least one month each year and over two billion people live in countries where water supply is inadequate. Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes. Improved water supply and sanitation, and better management of water resources, can boost countries' economic growth and can contribute greatly to poverty reduction.

The objective of this project is to construct an integrated sensor platform that can enable continuous monitoring of a water tank to the user, providing real-time data different water quality parameters.

Introduction

Our work started in the field of Green Buildings, and we engaged in substantial exploration of the various emerging technologies in the field. Following detailed discussion about Building analytics, our group zeroed down upon three distinct ideas we considered suitable to work upon, which were:

- IoT-based Building Management Cloud Platform for IIEST Shibpur
    - The goal is to develop a building management cloud Platform for IIEST Shibpur, by using the technologies of cloud computing and Internet of things.
    - The cloud servers would provide data storage, computing and hosting abilities.
    - The software would be able to take the responsibility for visualization interfaces and modularization services.
    - If there already exists a building management system for IIETS, we can try to expand its capabilities such as monitoring, controlling, data processing, management and services customization and try to integrate in the building management cloud platform. [1]

- Applying Machine Learning to Accurately Estimate the Heating and Cooling Load for an HVAC system
    - The goal is to accurately estimate the heating and cooling load on an HVAC system.
    - This can be accurately achieved using machine learning algorithms to process existing data from HVAC systems.
    - Heating, ventilation, and air conditioning consume 35% of total building energy which is the highest among all sources.
    - Understanding the patterns in heating and cooling load for an HVAC system can provide a better understanding of the energy used by HVAC in a certain climate. [2]

- Development of a low-cost IoT Based Water Management System for a residential building at IIEST Shibpur
    - The goal is to develop a low-cost IoT based water management system for a residential building at IIEST Shibpur.
    - This can be effectively achieved using a variety of sensors, IoT, and the various abilities offered by cloud platforms.
    - We can try to measure the amount of water supplied to a particular building.
    - The data can be used to effectively aware the residents of the building about their water usage and conservation as well as it may help to detect anomalies which may help to avoid loss of water due to late maintenance issues.[3]

Among the possible ideas we considered, we finally decided that developing a low-cost IoT Based Water Management System for a residential building at IIEST Shibpur was the project most suitably aligned with our interests, skills, capabilities, and the resources available to us. However, due to the aforementioned resource constraints we shall develop a system which is smaller in scale.

Fundamentals of IoT

The Internet of Things (IoT) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools. With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 10 billion by 2020 and 22 billion by 2025. Oracle has a network of device partners. [4]

A typical IoT system works through the real-time collection and exchange of data. An IoT system has three components:

- **Smart devices**

  This is a device, like a television, security camera, or exercise equipment that has been given computing capabilities. It collects data from its environment, user inputs, or usage patterns and communicates data over the internet to and from its IoT application.

- **IoT application**

  An IoT application is a collection of services and software that integrates data received from various IoT devices. It uses machine learning or artificial intelligence (AI) technology to analyze this data and make informed decisions. These decisions are communicated back to the IoT device and the IoT device then responds intelligently to inputs.

- **A graphical user interface**

  The IoT device or fleet of devices can be managed through a graphical user interface. Common examples include a mobile application or website that can be used to register and control smart devices. [5]

Sensors

The various sensors used in this work are explained in the following section.

1. **Turbidity sensor**

Turbidity is the calculation of the water clearness, i.e. the number of particles suspended in the water. It uses light to detect suspended particles to evaluate light transmit and dispersion rate. The calculation measures the numbers of water particles floating in the water, for example, plant waste, sand, silt and clay, impacting the sunlight in water [6]. Excess turbidity can reduce marine life reproduction and lead to various types of human illness [7]. The rate changes with the total number of particles suspended in water. Total Suspended Solids (TSS) increases in water with increasing turbidity. The input voltage of the sensor is 5V with an analog output voltage ranging from 0 to 4.5V. It can withstand a maximum temperature of 100 C–900 C. The NTU (Nephelometric Turbidity Units) is its units. In essence, the sensor is positioned to the side of the beam. When light reaches the sensor, if many small particles are dispersed in the water, this small particle will be detected by the source beam.

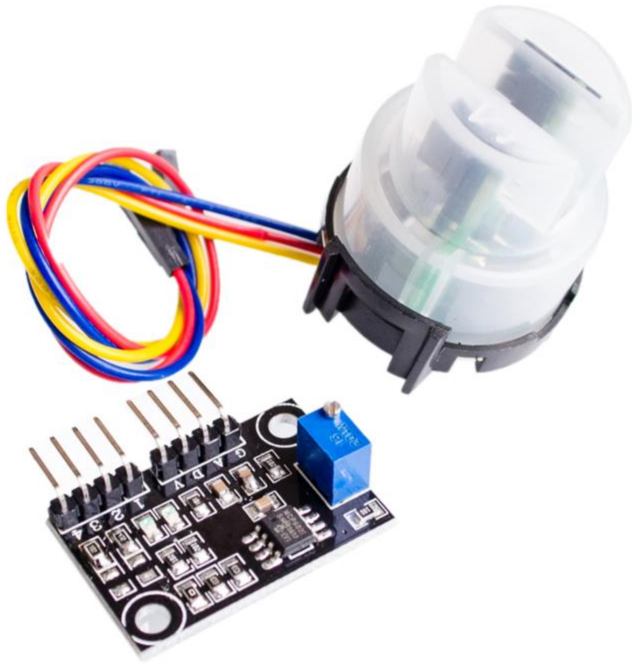


Figure 1. Turbidity Sensor

2. Ultrasonic Sensor

The ultrasonic sensor provides a 2cm - 4m measurement range. The sensor fabricated on a module that includes an ultrasonic transmitter (Trigger pin), receiver (Eco pin) and a control circuit. It generates a high-frequency sound wave of frequency 40 kHz, and it will be the valuation of the echo received by the sensor measures the interval between signal transmission from the pin trigger and receiving it back to the echo which further determines the distance to an object [8].

Figure 2. Ultrasonic Sensor

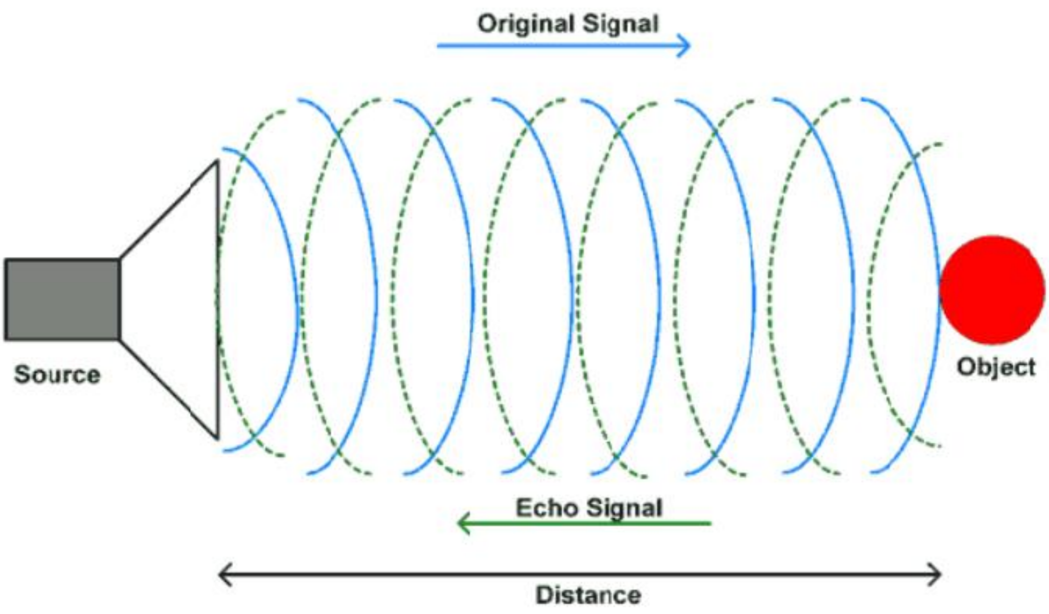


Fig. 2

Distance Calculation using Ultrasonic Sensor

We know that,

Distance = Speed x Time

The speed of sound waves is 343 m/s.

Distance = 343 x (Time of Echo Pulse) / 2

Total distance is divided by 2 because signal travels from the ultrasonic sensor to object and returns to the module.

3. Temperature Sensor

This sealed digital temperature probe lets you precisely measure temperatures in wet environments with a simple 1-Wire interface. The DS18B20 provides 9 to 12-bit (configurable) temperature readings over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor[9]. It is used to to determine the temperature of the atmosphere so that the pH and turbidity sensors are worked correctly over a long time.

Temperature measurement can also determine the kinds of marine organisms that can survive in the water[10].

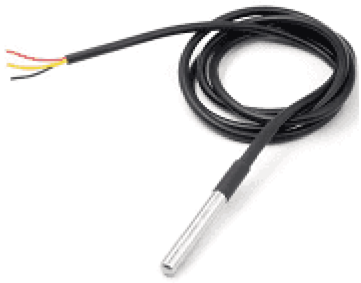


Figure 3. Temperature Sensor

4. pH Sensor

pH is a measure of the hydrogen ion concentration in solution and is also referred to as the degree of acidity or alkalinity [11]. The calculation is an acidity balancing test or the alkaline content of the ions of hydrogen in the water . The source of pH natural for water is about 7; pH ranges from 6.5 to 9.5 which can be considered safe water for drinking[12]. A pH sensor has an electrode of measurement and reference. The ion of hydrogen is sensitive to electrode measurement that has a potential directly linked to the hydrogen solution ion concentration. The electrical differential tension depends on the temperature so that the temperature sensor is also needed to correct the voltage shift [8].

Figure 4. pH Sensor

Arduino IDE

The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++. Here, IDE stands for Integrated Development Environment.

The program or code written in the Arduino IDE is often called as sketching. We need to connect the Genuino and Arduino board with the IDE to upload the sketch written in the Arduino IDE software. The sketch is saved with the extension '.ino.' [13] The Arduino IDE will appear as:

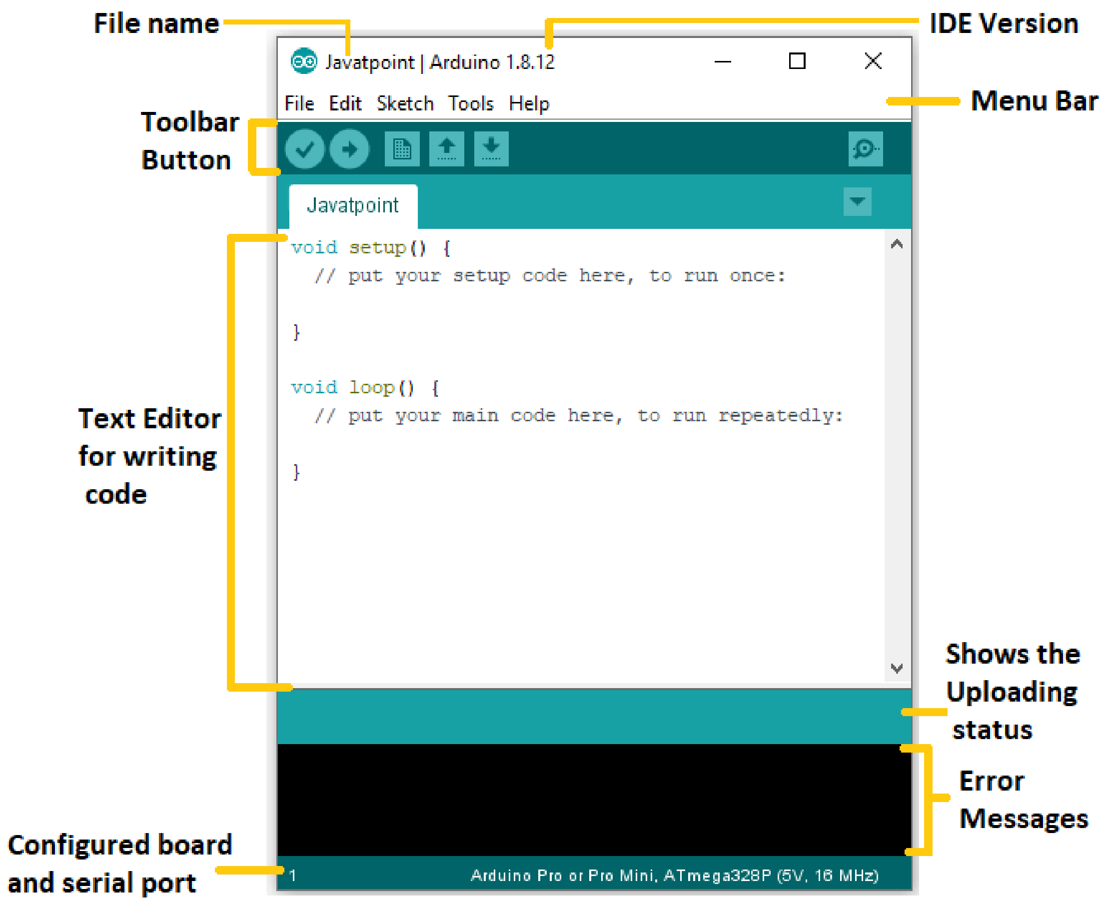


Figure 4. Arduino IDE

Blynk IoT

Blynk is a simple and powerful no-code application builder where you can prototype, deploy, and manage connected electronic devices at any scale - from your personal projects to millions of products used by your clients. It can connect hardware like ESP32, Arduino, Raspberry Pi, Seeed, Particle, SparkFun, Adafruit, TI, and others to the cloud and use a wide variety of widgets like buttons, sliders, charts, etc. to build a user interface to visualize sensor data and control any electronics [14].

It has following features:

- ❖ Ready for end-users
- ❖ Blynk is also a very user-friendly IoT app for anyone else. Once devices are activated, users can:
- ❖ Easily connect supported devices
- ❖ Remotely control supported devices from anywhere in the world
- ❖ Add and control multiple devices with a single app
- ❖ Receive real-time push and email notifications
- ❖ Create Automations: Make devices smarter by creating scenarios for one or between multiple devices. Based on device state, day, time, sunset or sunrise, and more.
- ❖ Manage access to devices by other people
- ❖ Interact with voice assistants like Amazon Echo and Google Home.

A representative screenshot of Blynk IoT is attached herewith:

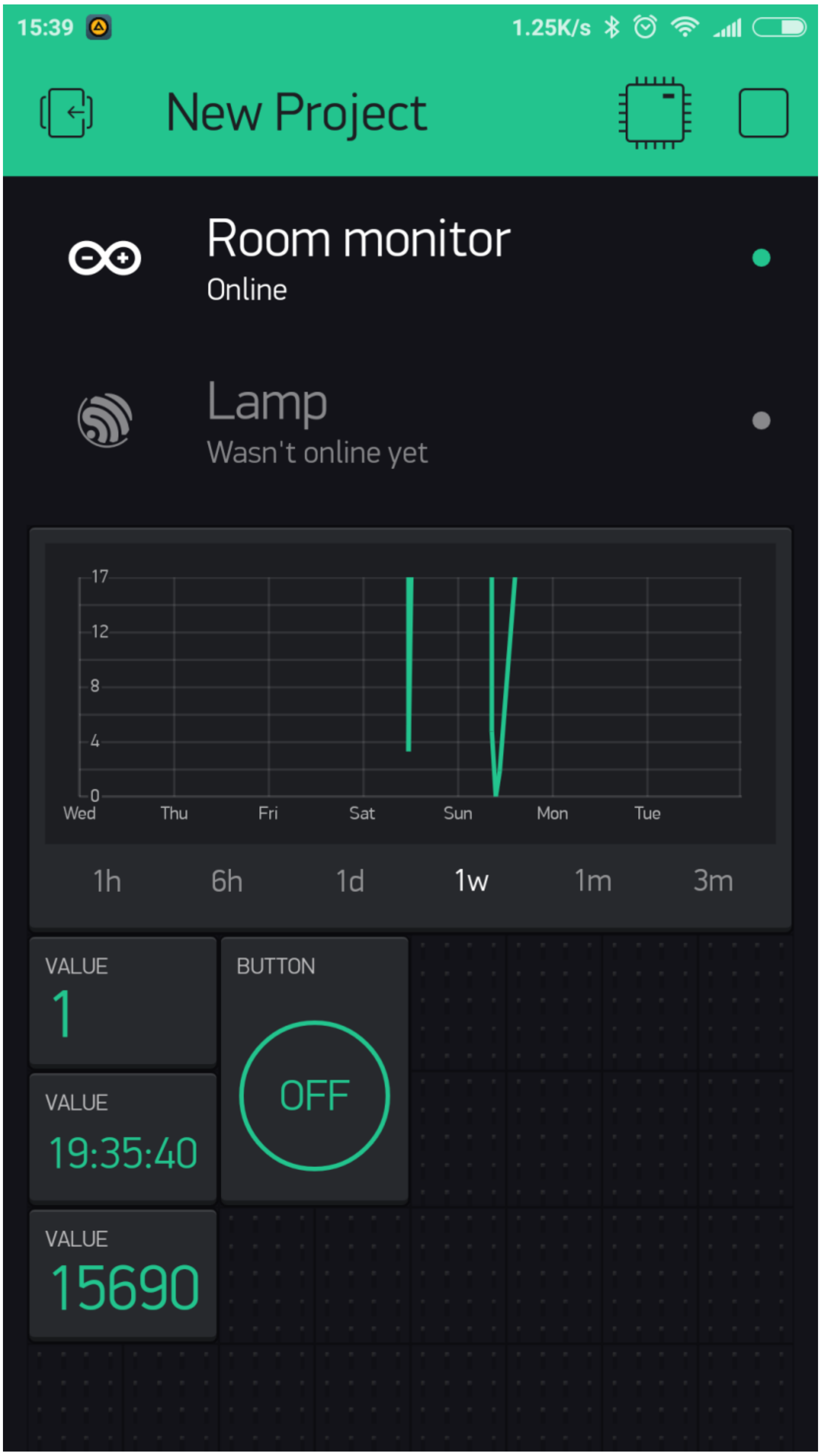


Figure 5. Representative Screenshot of Blynk IoT

Methodology

The proposed system shall have a tank containing water in which pH, temperature and turbidity sensors are immersed for water quality measurement and ultrasonic sensor is kept at the top for determining the water level. These sensors measure the corresponding valuesZ in the water. Outputs of analog systems can be converted into digital data using Arduino IDE. The readings of temperature and turbidity shall be shown on the LED screen as well as on Blynk IoT platform. The readings of pH and water level shall be shown only on the Blynk IoT platform.

This proposed system can be visualised on the following block diagram:

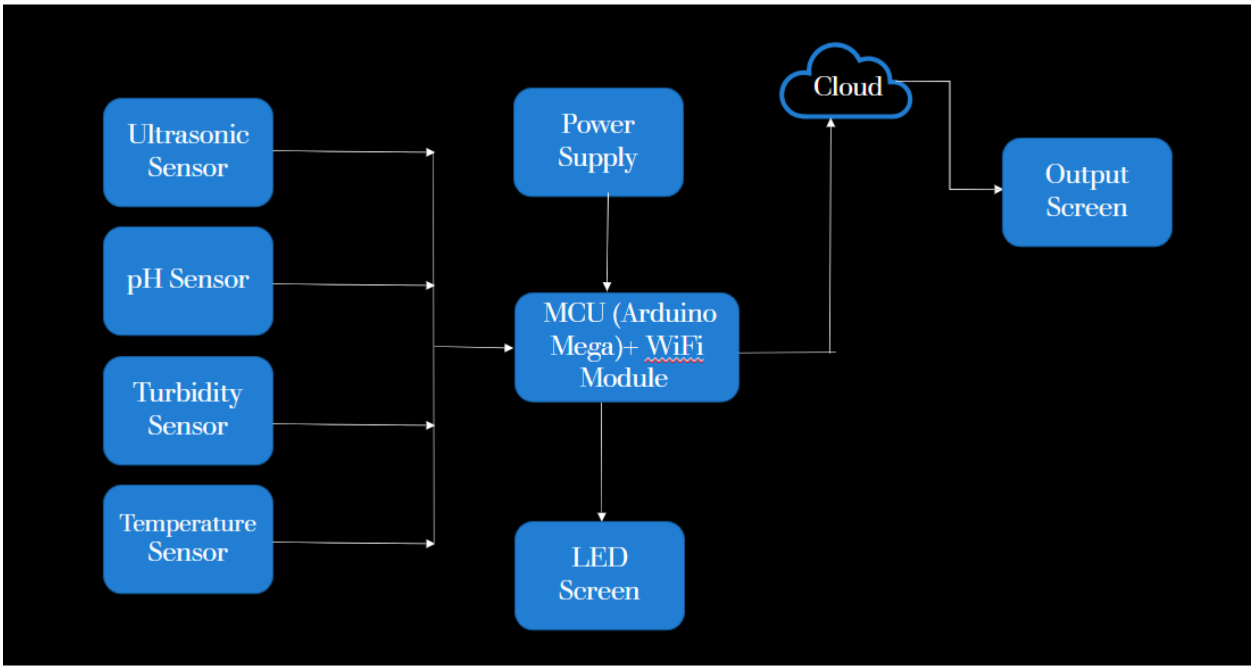


Figure 6. Block Diagram of the Proposed System

However, two of the sensors, namely ultrasonic sensor and pH sensor, that we purchased to implement this system, turned out to be malfunctioning and hence we had to limit ourselves to the PoC containing the remaining two sensors, namely temperature sensor and turbidity sensor. Therefore, the final PoC looked as follows:

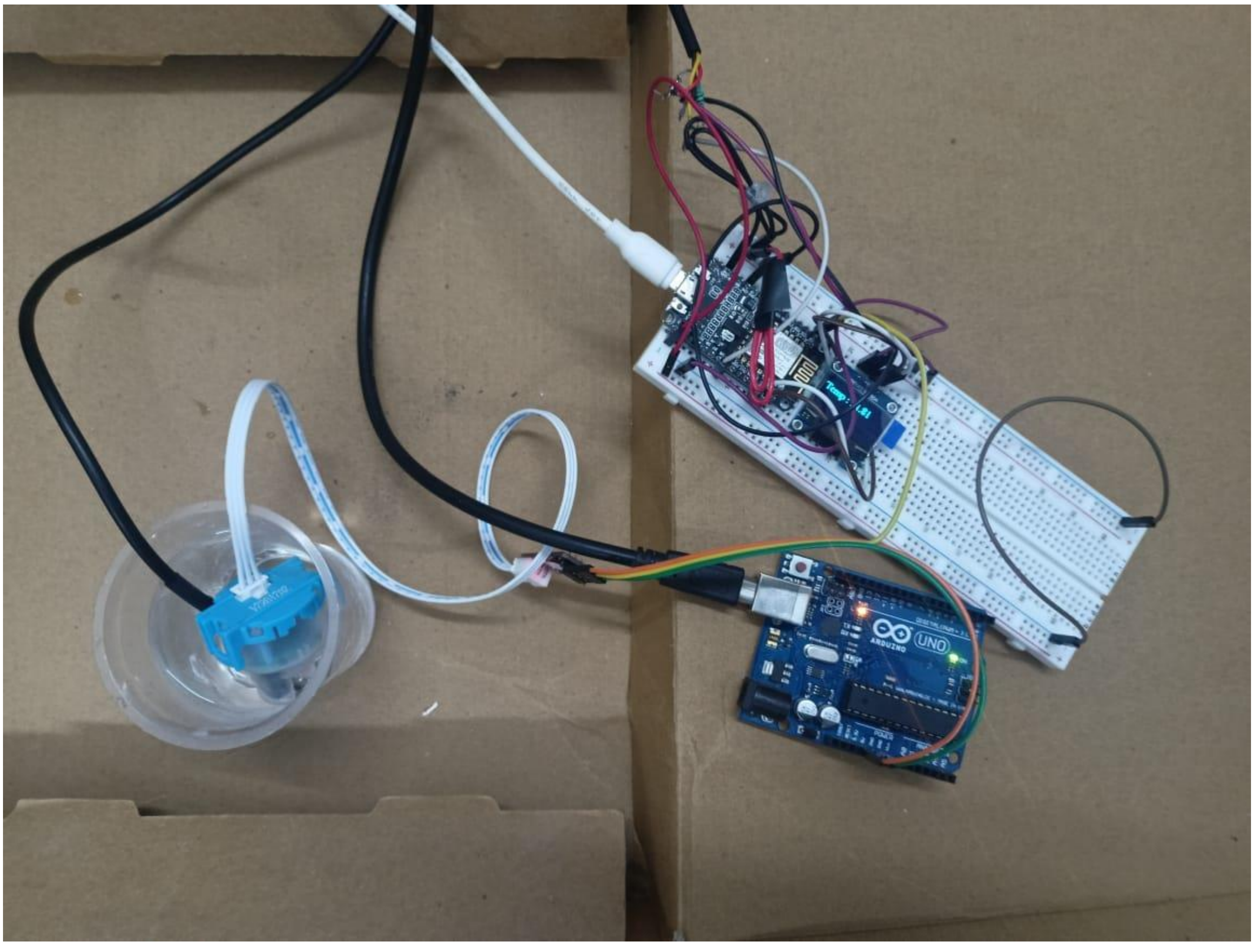


Figure 6. Final PoC

Results

Calibration of Turbidity Sensor

Using a standard Turbidity Meter, we have calibrated the turbidity sensor used in this system. We got the following table from the calibration process:

Voltage in Volts	Turbidity in NTU
3.43	53.3
3.36	99
3.5	35
3.65	1
3.54	20
3.49	67.5
3.41	86
3.33	92

Table 1: Calibration of Turbidity Sensor

According to the below equation, the Turbidity of water is inversely proportional to the voltage water.

$$\boldsymbol{y = -1120.4x^2 + 5742.3x - 4423.8}$$

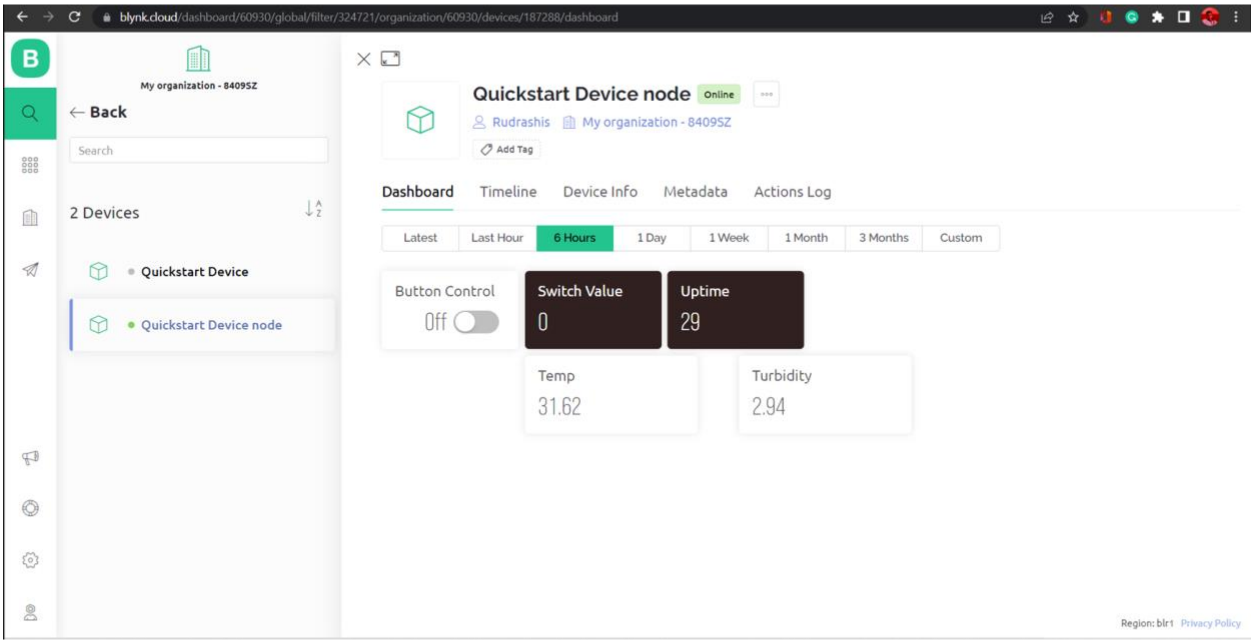
The above equation is used to find corresponding turbidity after getting the voltage values from turbidity sensor.

Calibration of pH Sensor

We tried calibrating a pH sensor as well in a similar manner as of turbidity sensor but due to some malfunctioning in the sensor, the values of voltage kept declining for every solution of varying pH starting from 2.4 to 12.5 until the value of voltage reached 0. Due to this, we could not use pH sensor in the system. However, a different pH sensor of higher cost could have been used but due to resource constraints, we ultimately didn't use pH sensor in the system.

The Working PoC

We had built a system that shows the temperature and turbidity of the water on Blynk IoT. A representative picture is given below:



Advantages and Limitations of the Proposed System

Following are the main advantages of the proposed system:

1. Cost-effective.
2. Real-time monitoring of water level and quality.
3. Energy efficient.
4. Easy to install.

5. Modular system.
6. Open-source code.

The proposed system has certain limitations as well which are described below:

1. **Requirement of internet connection.**
   The operation of the circuit depends on the working internet connection. If the working internet connection is not available then it will not run.
2. **Dependency on 3rd party server.**
   It also depends on the free server provided by the third party, if the free server is not working then it will not run.
3. **Requirement of timely calibrations for sensors.**
   The sensors used in the system may start to give false readings if they are damaged by any means. Hence, in order to be certain about the readings, the sensors must be calibrated timely.

Conclusion

The system proposed in this reoprt is an efficient, inexpensive IoT solution for real-time water level and quality monitoring. The developed system having Arduino Mega and NodeMCU target boards are interfaced with several sensors successfully. An efficient algorithm is developed in realtime, to track two water quality parameters. A web-based application i.e., Blynk IoT is used to monitor the parameters such as the turbidity of the water and temperature of the water through the web server. Similar work needs to be carried out to analyse several other parameters like electrical conductivity, free residual chlorine, nitrates, and dissolved oxygen in the water. OLED screen used in the system shows the temperature.

Our developed PoC works in accordance with the project objective. As a future directive, we would like to suggest that the sensors being used should be well calibrated and checked.

Future Scope

Monitoring other water quality parameters:

In the developed system, we have used sensors for only two water quality parameters i.e. temperature and turbidity however there are more water quality parameters that should be considered to make the system more holistic such as dissolved oxygen, conductivity, pH etc.

Automating the control over water pump:

The project can be further enabled to automated control over the water level in the tank, enabled by the ability to turn on the water pump when the water level in the tank reaches a predefined lower limit and then turning it off when the water level in the tank reaches another predefined upper limit.

Adding UI for better understanding of the user:

UI can be added on this system to make the user of this system understand the level of water, turbidity and temperature understand easily.

Informing about the amount of water used to the user on daily basis:

Per capita water consumed can be calculated if the number of individuals using a single water tak is known. It can also help to insight if there is an accidental wastage/ leakage of water and you can take the necessary actions.

Shifting the system to a paid server:

In this system, we have used free server but to scale it up and also to get security for the system, it can be shifted to some paid server.

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13. https://www.javatpoint.com/arduino-ide
14. https://blynk.io/

Appendix

Arduino IDE Code

```
/************************************************************

  This is a simple demo of sending and receiving some data.

  Be sure to check out other examples!

 ************************************************************/

#include <Wire.h>

#include <Adafruit_GFX.h>

#include <Adafruit_SSD1306.h>

#include <Fonts/FreeSerif9pt7b.h>

#define SCREEN_WIDTH 128 // OLED display width, in pixels

#define SCREEN_HEIGHT 64 // OLED display height, in pixels

// Declaration for an SSD1306 display connected to I2C (SDA, SCL pins)

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, -1);

#include <DallasTemperature.h>

#include <OneWire.h>
```

```
#define ONE_WIRE_BUS 14                    //D3 pin of nodemcu

OneWire oneWire(ONE_WIRE_BUS);

DallasTemperature sensors(&oneWire);            // Pass the oneWire reference to Dallas Temperature.

// Template ID, Device Name and Auth Token are provided by the Blynk.Cloud
// See the Device Info tab, or Template settingsinclude
#define BLYNK_TEMPLATE_ID           "TMPLjnoh-a-t"
#define BLYNK_DEVICE_NAME           "Quickstart Device"
#define BLYNK_AUTH_TOKEN            "fJ5uTocBrqc2E_qEXEVo1O45tFxaKjNx"


// Comment this out to disable prints and save space
#define BLYNK_PRINT Serial


#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

char auth[] = BLYNK_AUTH_TOKEN;

// Your WiFi credentials.
// Set password to "" for open networks.
```

```
char ssid[] = "Rudrashis";
char pass[] = "freeloader";

BlynkTimer timer;

// This function is called every time the Virtual Pin 0 state changes
BLYNK_WRITE(V0)
{
  // Set incoming value from pin V0 to a variable
  int value = param.asInt();

  // Update state
  Blynk.virtualWrite(V1, value);
}

// This function is called every time the device is connected to the Blynk.Cloud
BLYNK_CONNECTED()
{
  // Change Web Link Button message to "Congratulations!"
  Blynk.setProperty(V3, "offImageUrl", "https://static-image.nyc3.cdn.digitaloceanspaces.com/general/fte/congratulations.png");
  Blynk.setProperty(V3, "onImageUrl", "https://static-image.nyc3.cdn.digitaloceanspaces.com/general/fte/congratulations_pressed.png");
  Blynk.setProperty(V3, "url", "https://docs.blynk.io/en/getting-started/what-do-i-need-to-blynk/how-quickstart-device-was-made");
```

```
}

// This function sends Arduino's uptime every second to Virtual Pin 2.
void myTimerEvent()
{
  // You can send any value at any time.
  // Please don't send more that 10 values per second.
  Blynk.virtualWrite(V2, millis() / 1000);
}


void temperature(){

  sensors.requestTemperatures();                // Send the command to get temperatures
  Serial.println("Temperature is: ");
  float temp = sensors.getTempCByIndex(0);
  Serial.println(temp);   // Why "byIndex"? You can have more than one IC on the same bus. 0 refers to the first IC on the wire
  display.clearDisplay();
  display.setCursor(0,20);
  display.print("Temp :") ;
  display.print(" ");
  display.println(sensors.getTempCByIndex(0));
  display.display();
  Blynk.virtualWrite(V4, temp);
```

```
}

void voltage(){

  Serial.println("Turbidity: ");

    float volt = 0;
    float ntu;
    for(int i=0; i<800; i++)
    {
        volt += ((float)analogRead(A0)/1024)*5;
    }
    volt = volt/800;
    display.println(volt);
    volt = volt - 0.82;
    if(volt < 2.5){
      ntu = 3000;
    }else{
      ntu = -1120.4*(volt*volt)+5742.3*volt-4423.8;
    }
```

```
  if(ntu < 0){
    ntu= 0 ;
  }

  float voltage = ntu ;
  Serial.println(voltage);
  //display.clearDisplay();
  //display.setCursor(0,20);
  display.print("Turbidity :") ;
  display.print(" ");
  display.println(voltage);

  display.display();
  Blynk.virtualWrite(V5, voltage);
  Blynk.virtualWrite(V6, volt);




}
void setup()
{
  // Debug console
  Serial.begin(115200);
```

```
if(!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
  Serial.println("SSD1306 allocation failed");
  for(;;);
}


sensors.begin();


display.setFont(&FreeSerif9pt7b);
display.clearDisplay();
display.setTextSize(1);
display.setTextColor(WHITE);
display.setCursor(0,20);


Blynk.begin(auth, ssid, pass);
//You can also specify server:
//Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
//Blynk.begin(auth, ssid, pass, IPAddress(192,168,1,100), 8080);
```

```
  // Setup a function to be called every second
  timer.setInterval(1000L, myTimerEvent);
  timer.setInterval(1000L, temperature);
  timer.setInterval(1000L, voltage);
}

void loop()
{

  Blynk.run();
  timer.run();
  // You can inject your own code or combine it with other sketches.
  // Check other examples on how to communicate with Blynk. Remember
  // to avoid delay() function!
}
```