**REAL-TIME RIVER WATER QUALITY MONITORING AND CONTROL SYSTEM**

**NALAIYA THIRAN PROJECT BASED LEARNING**

**On**

**PROFESSIONAL READINESS FOR INNOVATION,**

**EMPLOYABILITY AND ENTREPRENEURSHIP**

**A PROJECT REPORT**

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**BACHELOR OF ENGINEERING**

**IN**

**ELECTRONICS AND COMMUNICATION ENGINEERING**

**SNS COLLEGE OF ENGINEERING**

**AN AUTONOMOUS INSTITUTION**

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**ABSTRACT**

Current water quality monitoring system is a manual system with a monotonous process and is very time-consuming. This paper proposes a sensor-based water quality monitoring system. The system consists of several sensors which is used to measure physical and chemical parameters of the water. The main components of Wireless Sensor Network (WSN) include a microcontroller for processing the system, communication system for inter and intra node communication and several sensors. Real-time data access can be done by using remote monitoring and Internet of Things (IoT) technology.

Now a day’s Internet of things (IoT) is an innovative technological phenomenon. It is shaping today’s world and is used in different fields for collecting, monitoring and analysis of data from remote locations. IoT integrated network if everywhere starting from smart cities, smart power grids, and smart supply chain to smart wearable. Though IoT is still under applied in the field of environment it has huge potential. It can be applied to detect forest fire and early earthquake, reduce air population, monitor snow level, prevent landslide, and avalanche etc. Moreover, it can be implemented in the field of water quality monitoring and controlling system. Water quality monitoring has gained more interest among researchers in this twenty-first century. Numerous works are either done or ongoing in this topic focusing on various aspects of it. The key theme of all the projects was to develop an efficient, cost-effective, real-time water quality monitoring system which will integrate wireless sensor network and internet of things. In this research, we monitor the physical and chemical parameters of water bodies inside Chittagong city by using an IoT based sensor network.

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## CHAPTER 1 INTRODUCTION

1. **INTRODUCTON**

The Internet of Things (IoT) is a system that allows devices to be connected and remotely monitored across the Internet. In the last years, the IoT concept has had a strong evolution, being currently used in various domains such as real-time river water quality monitoring and control system, telemedicine, industrial environments, etc. According to Human Rights Watch, twenty million people in our country are still drinking water contaminated with arsenic. The World health Organization (WHO) has also stated this crisis as "the largest mass poisoning of a population in history”. To reduce the water related diseases and prevent water population, we have to measure water parameters such as pH, turbidity, conductivity, temperature etc. Traditional methodology of water monitoring requires collecting data from various sources manually. Afterwards samples will be sending to laboratory for testing and analyzing. In order to save time consumption and decrease manual effort my testing equipment’s will be placed in any water source. As a result, this model can detect pollution remotely and take necessary actions.

### 1.2.COMPANY PROFILE

International Business Machines Corporation (IBM) is a technology company engaged in providing hybrid cloud and artificial intelligence (AI) solutions. It offers integrated solutions and products that use data and information technology (IT) in industries and business processes. Its segments include Software, Consulting, Infrastructure and Financing. Software segment consists of two business areas: Hybrid Platform & Solutions, which includes software to help clients operate, manage, and optimize their IT resources and business processes within hybrid, multi-cloud environments, and Transaction Processing, which includes software that supports clients’ mission-critical, on-premises workloads in various sectors. Consulting segment is engaged in business transformation, technology consulting and application operations. Infrastructure segment is engaged in hybrid infrastructure and infrastructure support. Financing segment is engaged in client financing and commercial financing business

**CHAPTER 2**

**OBJECTIVE**

### OBJECTIVE

Project based learning are generally thought of to be reserved for college students looking to gain experience in a particular field. However, the aim is to develop a system for continuous monitoring of river water quality at remote places using wireless sensor networks with low power consumption, low-cost and high detection accuracy. pH, conductivity, turbidity level, etc. are the limits that are analyzed to improve the water quality. The main objective of this project is to

* Gain knowledge of Watson IoT Platform.
* Connecting IoT devices to the Watson IoT platform and exchanging the sensor data.
* Gain knowledge on Cloudant DB
* Creating a Web Application through which the user interacts with the device.

This project makes the human work much easier.

### 2.1.TECHNOLOGY

The Internet of things (IoT) describes physical objects with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks. IoT is a giant, digitally connected universe of billions of physical devices around the world; “things” that collect and share data about how they’re used and the environment around them. These objects are embedded with internet connectivity, software, sensors, and other hardware that enable them to connect and exchange data with other systems and devices over the web. IoT extends the power of the internet beyond smartphones and computers to ordinary household objects such as lightbulbs, locks, smart microwaves, wearable fitness devices, sophisticated industrial tools, and self-driving cars, affording them a higher degree of analytical and computing capabilities

**CHAPTER 3**

**IDEATION PHASE**

1. **IDEATION PHASE**

**3.1 Literature Survey**

In order to support our project, the below mentioned literature were reviewed.

1. **Water Quality Monitoring Using Wireless Sensor Networks: Current Trends and Future Research Directions**

**Author :** Kofi Sarpong Adu-Manu, Cristiano Tapparello, Wendi Heinzelman, Ferdinand Apietu Katsriku, and JamalDeen Abdulai.

**Year :** 2017.

**Link :** <http://dx.doi.org/10.1145/3005719>

Water is essential for human survival. Although approximately 71% of the world is covered in water, only 2.5% of this is fresh water; hence, fresh water is a valuable resource that must be carefully monitored and maintained. In developing countries, 80% of people are without access to potable water. Cholera is still reported in more than 50 countries. In Africa, 75% of the drinking water comes from underground sources, which makes water monitoring an issue of key concern, as water monitoring can be used to track water quality changes over time, identify existing or emerging problems, and design effective intervention programs to remedy water pollution. It is important to have detailed knowledge of potable water quality to enable proper treatment and also prevent contamination. In this article, we review methods for water quality monitoring (WQM) from traditional manual methods to more technologically advanced methods employing wireless sensor networks (WSNs) for in situ WQM. In particular, we highlight recent developments in the sensor devices, data acquisition procedures, communication and network architectures, and power management schemes to maintain a long-lived operational WQM system. Finally, we discuss open issues that need to be addressed to further advance automatic WQM using WSNs.

1. **Sensor based water quality monitoring system**

**Author :** Paul, Bishwajit.

**Year :** 2018.

**Link :** <http://dspace.bracu.ac.bd/xmlui/handle/10361/10840>

According to Human Rights Watch, twenty million people in our country are still drinking water contaminated with arsenic. The World health Organization (WHO) has also stated this crisis as "the largest mass poisoning of a population in history”. To reduce the water related diseases and prevent water population, we have to measure water parameters such as ph, turbidity, conductivity, temperature etc. Traditional methodology of water monitoring requires collecting data from various sources manually. Afterwards samples will be sending to laboratory for testing and analyzing. In order to save time consumption and decrease manual effort my testing equipment’s will be placed in any water source. As a result, this model can detect pollution remotely and take necessary actions. The main goal of this paper to build a Sensor- based Water Quality Monitoring System. Arduino Mega 2560 act as a base station and data from sensor nodes will be send to it. For the academic purpose, this paper presents a small prototype of sensor networks consisting of temperature, water level, flow and ph. Then ph. and temperature sensor values were sent cloud platform (ARTIK cloud) and displayed as a graphical representation on a local PC. Moreover, GSM shield (SIM808) is connected to Arduino Mega which compares sensor values to threshold values and sends a text alert to the agent if the obtained value is above or below the threshold value. The results of this project are discussed in the result section of the paper. We tested three water samples from three different water sources (such as industrial water, tap water and swimming pool water). Three water samples collected from three different swimming pools.(Except one sample) Ph value found in rest of the samples were in normal range (temperature value between 26-27’C). Result section (in page 20) explains our project findings in details.

### Real-time water quality monitoring using Internet of Things in SCADA

**Author :** K. Saravanan, E. Anusuya, Raghvendra Kumar & Le Hoang So

**Year :** 2018.

**Link :** <https://link.springer.com/article/10.1007/s10661-018-6914-x>

Water pollution is the root cause for many diseases in the world. It is necessary to measure water quality using sensors for prevention of water pollution. However, the related works remain the problems of communication, mobility, scalability, and accuracy. In this paper, we propose a new Supervisory Control and Data Acquisition (SCADA) system that integrates with the Internet of Things (IoT) technology for real-time water quality monitoring. It aims to determine the contamination of water, leakage in pipeline, and also automatic measure of parameters (such as temperature sensor, flow sensor, color sensor) in real time using Arduino at mega 368 using Global System for Mobile Communication (GSM) module. The system is applied in the Tirunelveli Corporation (Metro city of Tamil Nādu state, India) for automatic capturing of sensor data (pressure, pH, level, and energy sensors). SCADA system is fine- tuned with additional sensors and reduced cost. The results show that the proposed system outperforms the existing ones and produces better results. SCADA captures the real-time accurate sensor values of flow, temperature, and color and turbidity through the GSM communication.

1. **IoT Based Real-time River Water Quality Monitoring System**

**Author :** Mohammad Salah Uddin Chowdhury, Talha Bin Emran, Subhashish Ghosh.

**Year :** 2019.

**Link :** <https://www.sciencedirect.com/science/article/pii/S1877050919309391>

Current water quality monitoring system is a manual system with a monotonous process and is very time-consuming. This paper proposes a sensor-based water quality monitoring system. The main components of Wireless Sensor Network (WSN) include a microcontroller for processing the system, communication system for inter and intra node communication and several sensors. Real-time data access can be done by using remote monitoring and Internet of Things (IoT) technology. Data collected at the apart site can be displayed in a visual format on a server PC with the help of Spark streaming analysis through Spark MLlib, Deep learning neural network models, Belief Rule Based (BRB) system and is also compared with standard values. If the acquired value is above the threshold value automated warning SMS alert will be sent to the agent. The uniqueness of our proposed paper is to obtain the water monitoring system with high frequency, high mobility, and low powered. Therefore, our proposed system will immensely help Bangladeshi populations to become conscious against contaminated water as well as to stop polluting the water.

### Real-time water quality monitoring using Internet of Things

**Author :** Mayuri Malunjkar, Sadhana Mare, Monika Nagawade.

**Year :** 2019.

## Link : [https://ijariie.com/AdminUploadPdf/Real\_time\_water\_quality\_monitoring](https://ijariie.com/AdminUploadPdf/Real_time_water_quality_monitoring_system_using__machine_learning_and_IoT_ijariie9812.pdf)

## [\_system\_using machine\_learning\_and\_IoT\_ijariie9812.pdf](https://ijariie.com/AdminUploadPdf/Real_time_water_quality_monitoring_system_using__machine_learning_and_IoT_ijariie9812.pdf)

There is need for effective monitoring, evaluation and control of water quality in different areas. Ensuring safe water supply of drinking water is big challenge for today’s generation. The excessive use of fertilizers in farms and also in other sectors such as mining and construction have contributed in overall reduction of water quality. To ensure the safe supply of the drinking water the quality needs to be monitor. So, we can give a design and development of a low-cost system for real time monitoring of the water quality using IoT(Internet of Things) and machine learning. The system include of different sensors is used for measuring physical and chemical parameters of the water.

**3.2 Empathy Map**

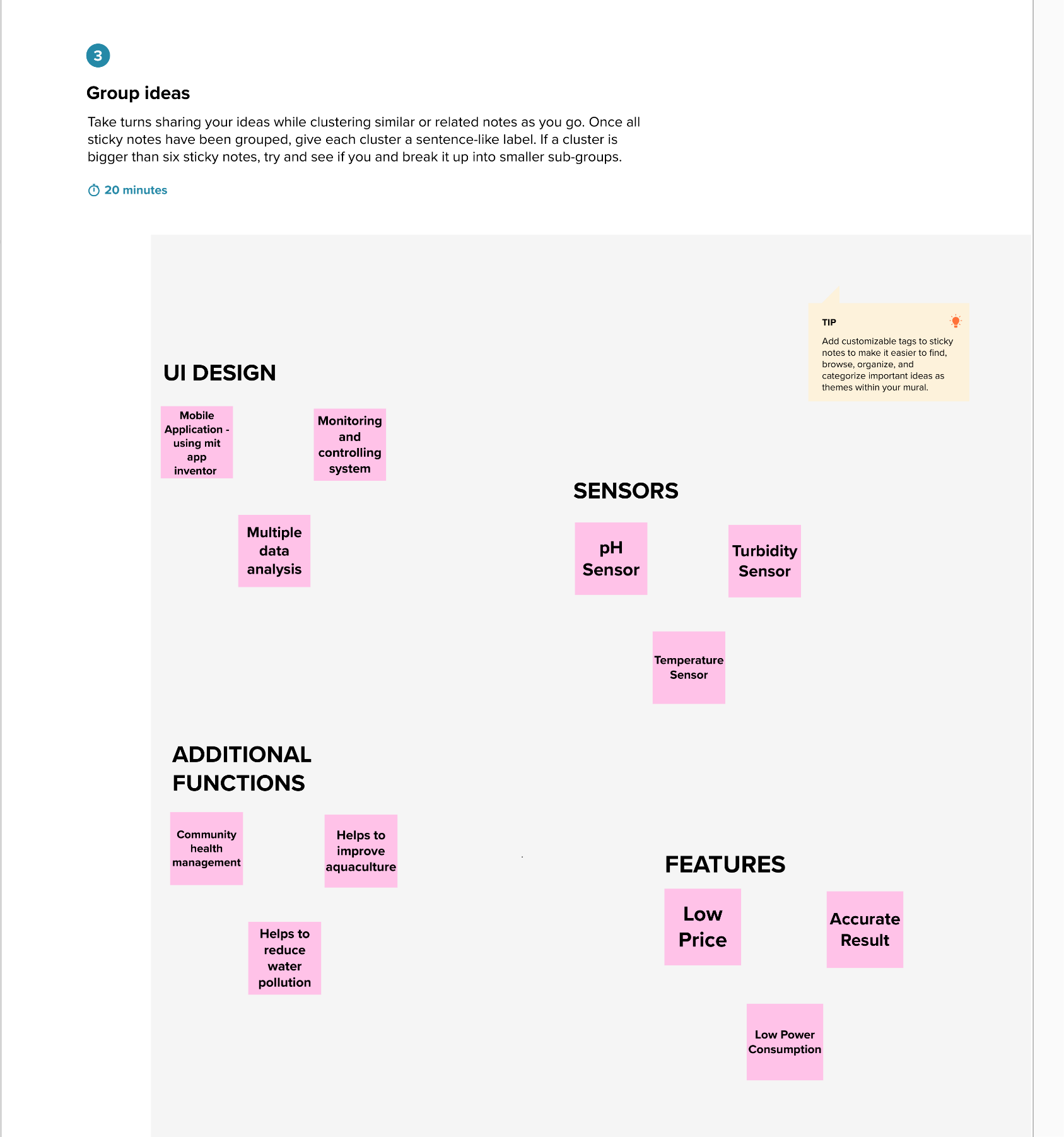
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**3.3 Ideation**

**Brainstorm & Idea Prioritization**

**Step-1: Team Gathering, Collaboration and Select the Problem Statement**



**Step-3: Idea Prioritization**



**3.4 Problem Statement**



|  |  |  |
| --- | --- | --- |
| **I am (Customer)** | An authorised person who is supposed to ensure the safety of common people. | Common people living on Earth who consume water in their day-to-day life for different purpose. So, it is necessary for authorizations to confirm that the water is safe. |
| **I’m trying to** | Monitor the quality of water. | Wants to monitor the water consumed every day and check whether the water is contaminated or pure, its pH, temperature and salinity. |
| **But** | The existing model is not accurate. | Accuracy is very important because the quality of water is a very sensitive content that can damage the lives of people and nature. |
| **Because** | The existing model is high cost, high power consumption and also it is not automated. | It is difficult to be alert about the lack of quality of water at every single time. |
| **Which makes me feel** | Concerned about the safety of people. | If the authorized people are not aware of the lack of water quality then they won’t be able to give alerts to people consuming that water, which will lead to a serious problem. |

**CHAPTER 4 PROJECT DESIGN PHASE 1**

1. **PROJECT DESIGN PHASE 1**

**4.1 Proposed Solution**

**Proposed Solution Template:**

Project team shall fill the following information in proposed solution template.

|  |  |  |
| --- | --- | --- |
| **S.No.** | **Parameter** | **Description** |
|  | Problem Statement (Problem to be solved) | Often people and other living organisms are suffered due to unavailability of pure usable water. Due to this health hazards and other infections are spreaded among people. In order to secure them it is necessary to develop a system to handle the quality of water. This can also help the people to have an idea on drinkable water. |
|  | Idea / Solution description | * So, to start this, we just need to know or have an idea on the chemical composition of water or simply the nature of water * Based on timely taken analysis we can find the nature of water . * Use a random location on taking the amount of chemicals and impurities present in water. |
|  | Novelty / Uniqueness | Low investment and maintainace cost , This system developed is useful and creates an ease of pure water consumption for natives as well as other beings. |
|  | Social Impact / Customer Satisfaction | * This helps the people to save time and energy as they can get pure river water with ease. * Building an effective system that can be create as a product for best water quality and control system. |
|  | Business Model (Revenue Model) | Many other parts of the world and rural parts of the village are expecting this technology that can greatly facilitate the river water quality management system. |
|  | Scalability of the Solution | The process of operating is easy and it can designed according to customer needs. |

**4.2 Problem Solution Fit**



**4.3 Solution Architecture**

**Solution Architecture:**

Alerts When The Quality Of Water Is Reduced

Stores The Data Into IBM Cloudant Db

Ph

Level And

Turbidity Of The

Water

Send Data To IBM IOT Watson Platform

Water

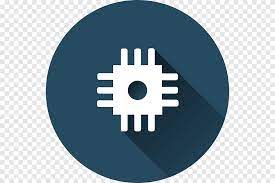
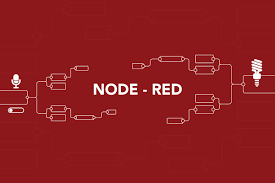
**Example –Solution Architecture Diagram:**

****

**CLOUD SERVICE**

****

**FAST SMS**

** **  ****

**IOT DEVICE**

****

**USER**

**WEB UI**

**NODE-RED**

**IBM WATSON IOT PLATFORM**

**PYTHON CODE**

**PROJECT DESCRIPTION:**

* River water quality can be monitored by the web application.
* The web application and the user are interfaced.
* The pH level and the turbidity of the water can be monitored.
* If the water quality is not good then the authorities get alerted by the message.

**CHAPTER 5**

**PROJECT DESIGN**

**PHASE 2**

1. **PROJECT DESIGN PHASE 2**

**5.1 Customer Journey Map**

****

**5.2 Requirement Analysis**

**Functional Requirements:**

Following are the functional requirements of the proposed solution.

|  |  |  |
| --- | --- | --- |
| **FR No.** | **Functional Requirement (Epic)** | **Sub Requirement (Story / Sub-Task)** |
| FR-1 | User Registration | 1. Registration through Gmail. 2. Registration through mobile number. |
| FR-2 | User Confirmation | 1. Confirmation via Email. 2. Confirmation via OTP. |
| FR-3 | User access | 1. Accepting all the terms and conditions. 2. Confirmation of recaptcha. |
| FR-4 | User mode | Online |
| FR-5 | User alert | Alert SMS to the registered mobile number if the measured value crosses the threshold value. |

**Non-functional Requirements:**

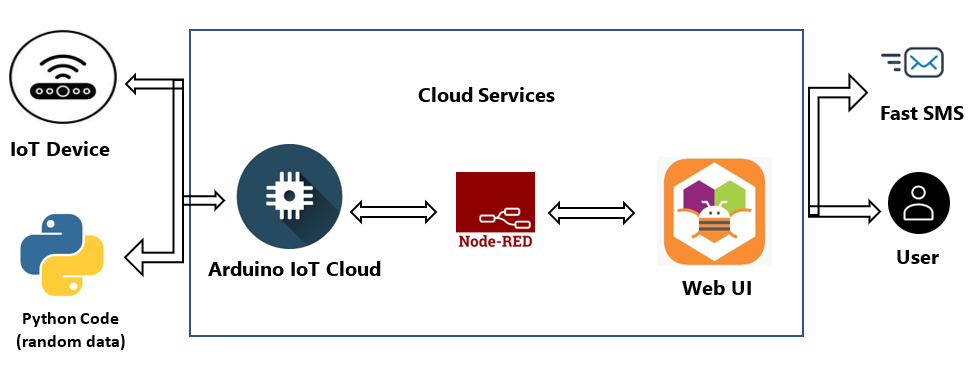
Following are the non-functional requirements of the proposed solution.

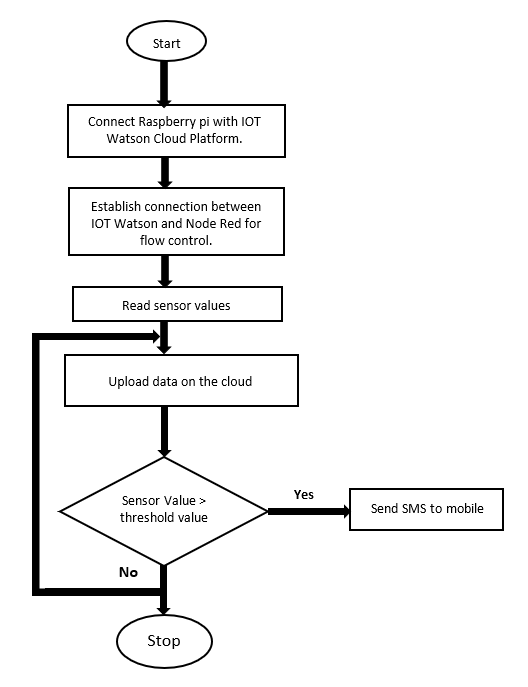
|  |  |  |
| --- | --- | --- |
| **FR No.** | **Non-Functional Requirement** | **Description** |
| NFR-1 | **Usability** | 1. Easy to use. 2. Effective, Efficient, Engaging, Error tolerant. 3. Easy to learn. |
| NFR-2 | **Security** | 1. Accepting Terms and Conditions. 2. Confirmation via Email and OTP. 3. Confirmation via recaptcha. 4. Strong cryptography skills. 5. Software security architects also have experience with malware, intrusion detection and prevention and firewalls. |
| NFR-3 | **Reliability** | 1. Great user interface. 2. Software operating without failure while in a specified environment over a set duration of time. |
| NFR-4 | **Performance** | Fast loading of the result time and high performance. |
| NFR-5 | **Availability** | Easy installation. |
| NFR-6 | **Scalability** | 1. Optimizing SQL queries and implementing indexing strategies. 2. By building articles and authors into a single query, we can dramatically reduce the volume of queries we're running. |

**5.3 Data Flow Diagrams**

**Data Flow Diagrams:**

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.



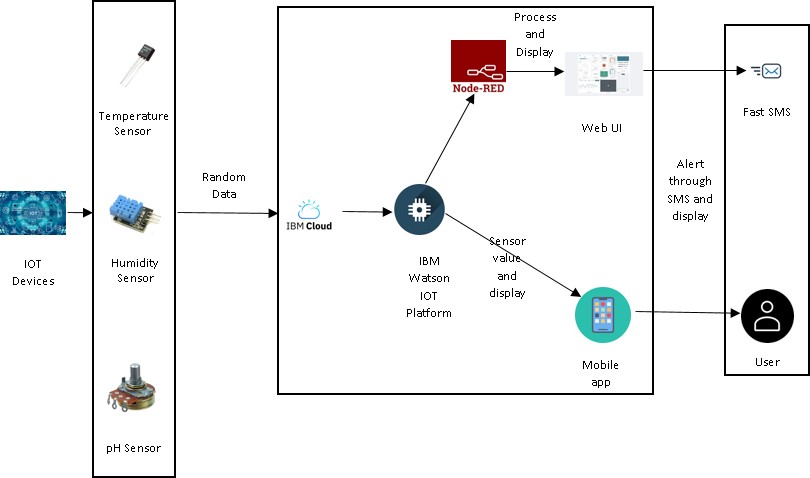




**5.4 Technology Stack**

**Technical Architecture:**

The Deliverable shall include the architectural diagram as below and the information as per the table1 & table 2



**Table-1 : Components & Technologies:**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Component** | **Description** | **Technology** |
| 1. | User Interface | Web UI, Mobile App | Node – Red, Kubernetes, MIT mobile app inventor |
| 2. | Application Logic-1 | Generate random data | Python |
| 3. | Application Logic-2 | Generate random sensor data | IBM Watson IOT Platform |
| 4. | Cloud Database | Database Service on Cloud | IBM DB2, IBM Cloudant, |
| 5. | External API-1 | Send SMS to customer | Fast SMS API |
| 6. | Infrastructure (Server / Cloud) | Application Deployment on Cloud | Cloud Foundry, Kubernetes |

**Table-2: Application Characteristics:**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.No** | **Characteristics** | **Description** | **Technology** |
| 1. | Open-Source Frameworks | the open-source tools we utilized to create our project | Node – Red, IBM Cloudant, IBM Watson IOT Platform |
| 2. | Security Implementations | Use of a login page with a user's unique username and password on a web interface  optimized for mobile devices and computers with adjustable screen sizes | Password protection in MIT App |
| 3. | Scalable Architecture | optimized for mobile devices and computers with adjustable screen sizes | Node – Red (Web UI) |
| 4. | Availability | accessible to users through both a web UI and a mobile app | Node – Red(Web UI), MIT App(Mobile App) |
| 5. | Performance | Give precise results and a prompt warning in the event of water contamination | Node – Red(Web UI), MIT App(Mobile App) |

**CHAPTER 6**

**PROJECT**

**PLANNING**

**PHASE**

**6 PROJECT PLANNING PHASE**

**6.1 Milestone and Activity List**

|  |  |  |
| --- | --- | --- |
| Title | Description | Date |
| Literature Survey on The Selected Project and Information Gathering | A Literature Survey is a compilation summary of research done previously in the given topic. Literature survey can be taken from books, research paper online or from any source | 10 October 2022 |
| Prepare Empathy Map | Empathy Map is a visualization tool which can be used to get a better insight of the customer. | 10 October 2022 |
| Ideation-Brainstorming | Brainstorming is a group problem solving session where ideas are shared, discussed and organized among the team members | 10 October 2022 |
| Define Problem Statement | A Problem Statement is a concise description of the problem or issues a project seeks to address. The problem statement identifies the current state, the desired future state and any gaps between the two | 10 October 2022 |
| Problem Solution Fit | This helps us to understand the thoughts of the customer their likes, behaviour, emotions etc. | 10 October2022 |
| Proposed Solution | Proposed solution shows the current solution and it helps is going towards the desired result until it is achieved. | 26 September 2022 |
| Solution Architecture | Solution Architecture is a very complex process i.e., it has a lot of sub-processes and branches. It helps in understanding the components and features to complete our project. | 26 September 2022 |
| Customer Journey | It helps us to analyse from the perspective of a customer, who uses our project. | 08 October 2022 |
| Functional Requirement | Here functional and non-functional requirements are briefed. It has specific features like usability, security, reliability, performance, availability and scalability. | 08 October 2022 |
| Data Flow Diagrams | Data Flow Diagram is a graphical or visual representation using a standardised set of symbols and notations to describe business operations through data movement. | 14 October 2022 |
| Technology Architecture | Technology Architecture is a better defined version of solution architecture. It helps us analyse and understand various technologies that need to be implemented in the project. | 14 October 2022 |
| Prepare Milestone & Activity List | It helps us to understand and evaluate our own progress and accuracy so far. | 11 November2022 |
| Sprint Delivery Plan | Sprint planning is an event in scrum that kicks off the sprint. The purpose of sprint planning is to define what can be delivered in the sprint and how that work will be achieved. | In Progress |

**6.2 Sprint Delivery Plan**

**Product Backlog, Sprint Schedule, and Estimation (4 Marks)**

Use the below template to create product backlog and sprint schedule

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sprint** | **Functional**  **Requirement (Epic)** | **User Story**  **Number** | **User Story / Task** | **Story Points** | **Priority** | **Team**  **Members** |
| Sprint-1 |  | US-1 | Creating IBM Cloud and using its services. | 6 | High | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |
| Sprint-1 |  | US-2 | Configure the IBM cloud service and creating IoT platform. | 4 | High | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |
| Sprint-1 |  | US-3 | IBM Watson IoT platform acts as the mediator to connect the web application to IoT devices, hence Launching IBM Watson IoT platform. | 5 | Low | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |
| Sprint-1 |  | US-4 | In order to connect the IoT device to the IBM Cloud, create a device in the IBM Watson IoT Platform and get the device credentials. | 5 | Medium | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |
| Sprint-2 |  | US-1 | Configure the connection security and create API keys that are used in the NODE-RED service for accessing the IBM IoT Platform. | 10 | High | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |

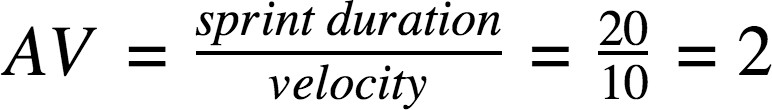
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sprint** | **Functional**  **Requirement (Epic)** | **User Story**  **Number** | **User Story / Task** | **Story Points** | **Priority** | **Team**  **Members** |
| Sprint-2 |  | US-2 | Create a Node-RED service. | 10 | High | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |
| Sprint-3 |  | US-1 | Develop a python script to publish random sensor data such as temperature, turbidity and pH to the IBM IoT Platform. | 7 | High | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |
| Sprint-3 |  | US-2 | After developing python code, commands are received just print the statements which represent the control of the devices. | 5 | Medium | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |
| Sprint-3 |  | US-3 | Publish data to the IBM Cloud. | 8 | High | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |
| Sprint-4 |  | US-1 | Create Web UI in Node-RED. | 10 | High | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |
| Sprint-4 |  | US-2 | Configure the Node-RED flow to receive data from the IBM IoT Platform and also use Cloudant DB nodes to store the received sensor  data in Cloudant DB. | 10 | High | Priyadharshini.V  Senthuriya.D  Swathi.S  Jothika.S |

**Project Tracker, Velocity & Burndown Chart: (4 Marks)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sprint** | **Total Story Points** | **Duration** | **Sprint Start Date** | **Sprint End Date (Planned)** | **Story Points**  **Completed (as on Planned End Date)** | **Sprint Release Date (Actual)** |
| Sprint-1 | 20 | 6 Days | 24 Oct 2022 | 29 Oct 2022 | 20 | 29 Oct 2022 |
| Sprint-2 | 20 | 6 Days | 31 Oct 2022 | 05 Nov 2022 | 20 | 05 Nov 2022 |
| Sprint-3 | 20 | 6 Days | 07 Nov 2022 | 12 Nov 2022 | 20 | 12 Nov 2022 |
| Sprint-4 | 20 | 6 Days | 14 Nov 2022 | 19 Nov 2022 | 20 | 19 Nov 2022 |

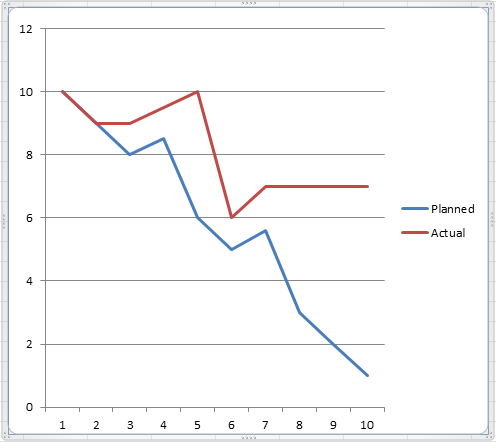
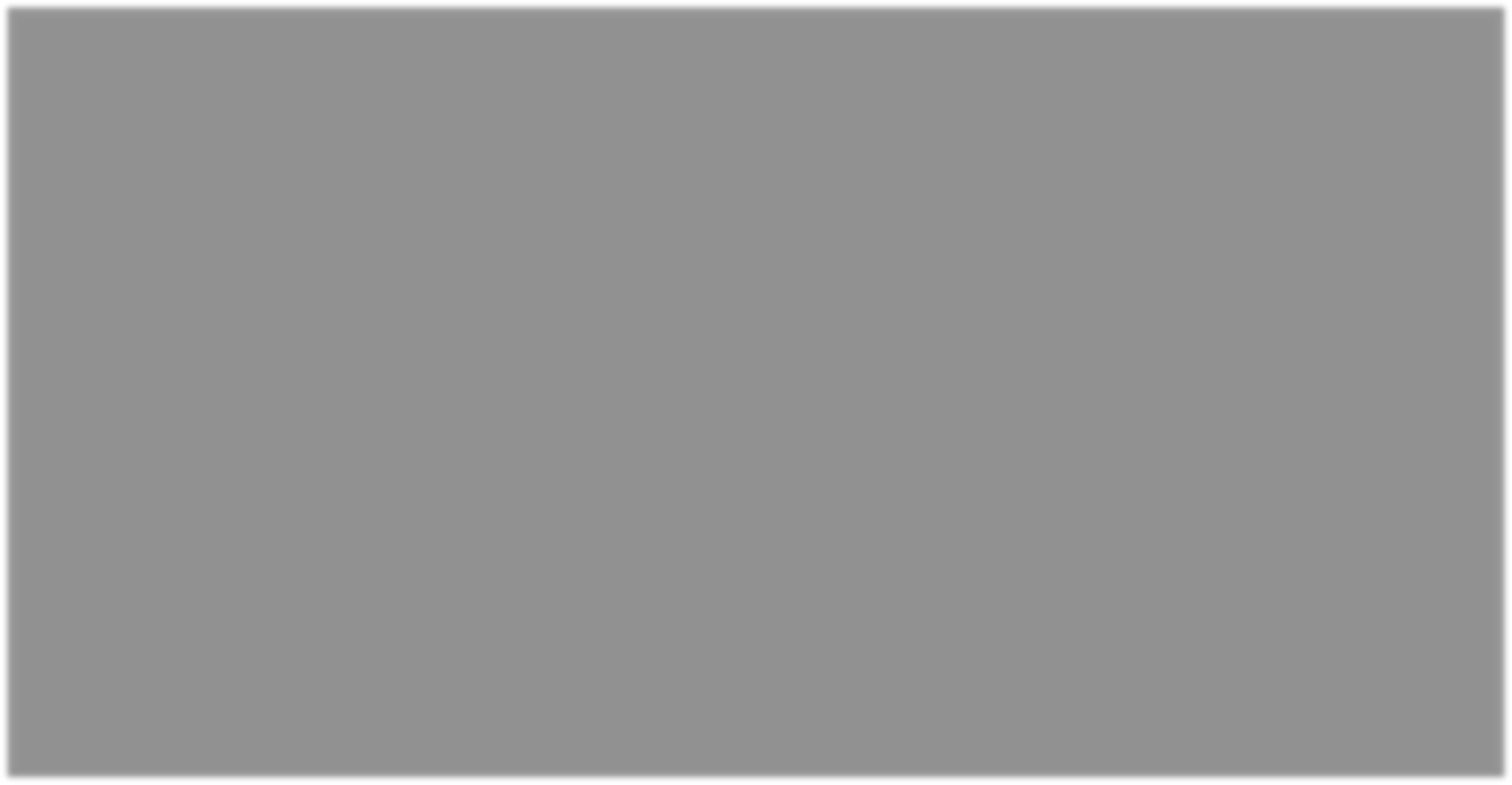
**Velocity:**

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let’s calculate the team’s average velocity (AV) per iteration unit (story points per day)



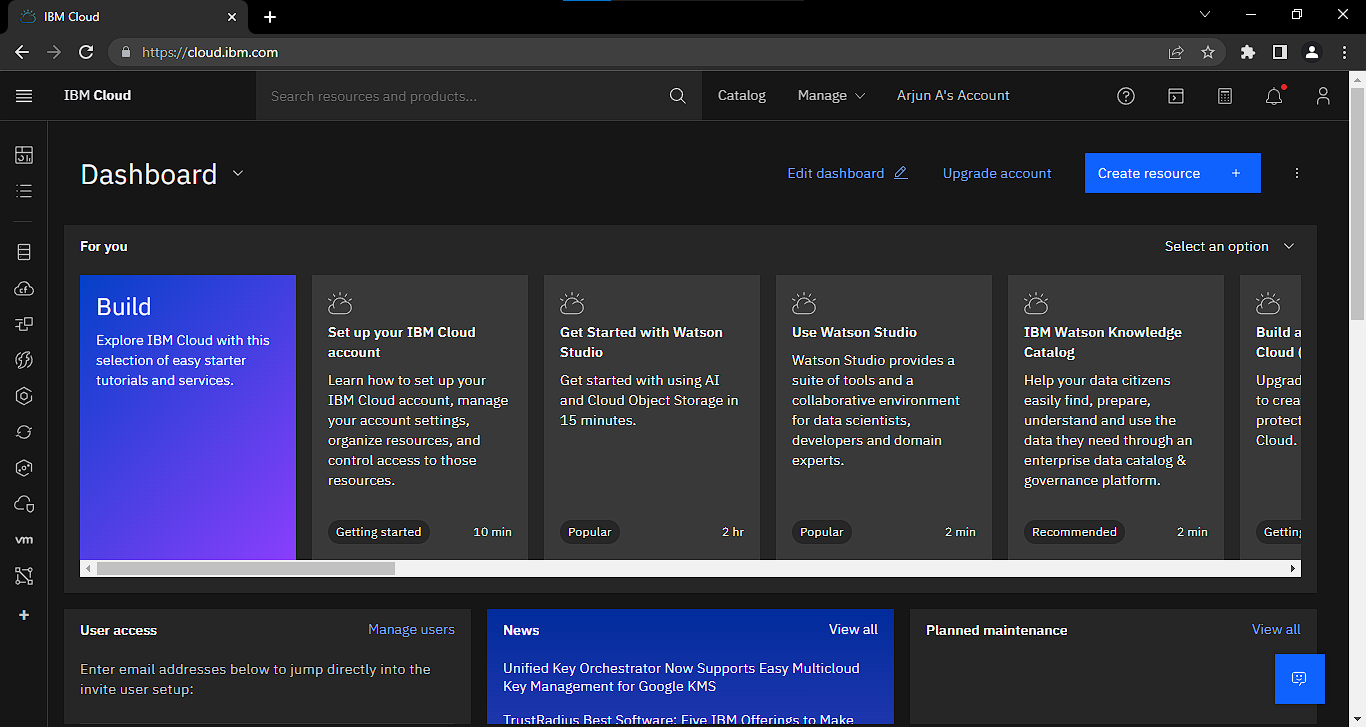
**Burndown Chart:**

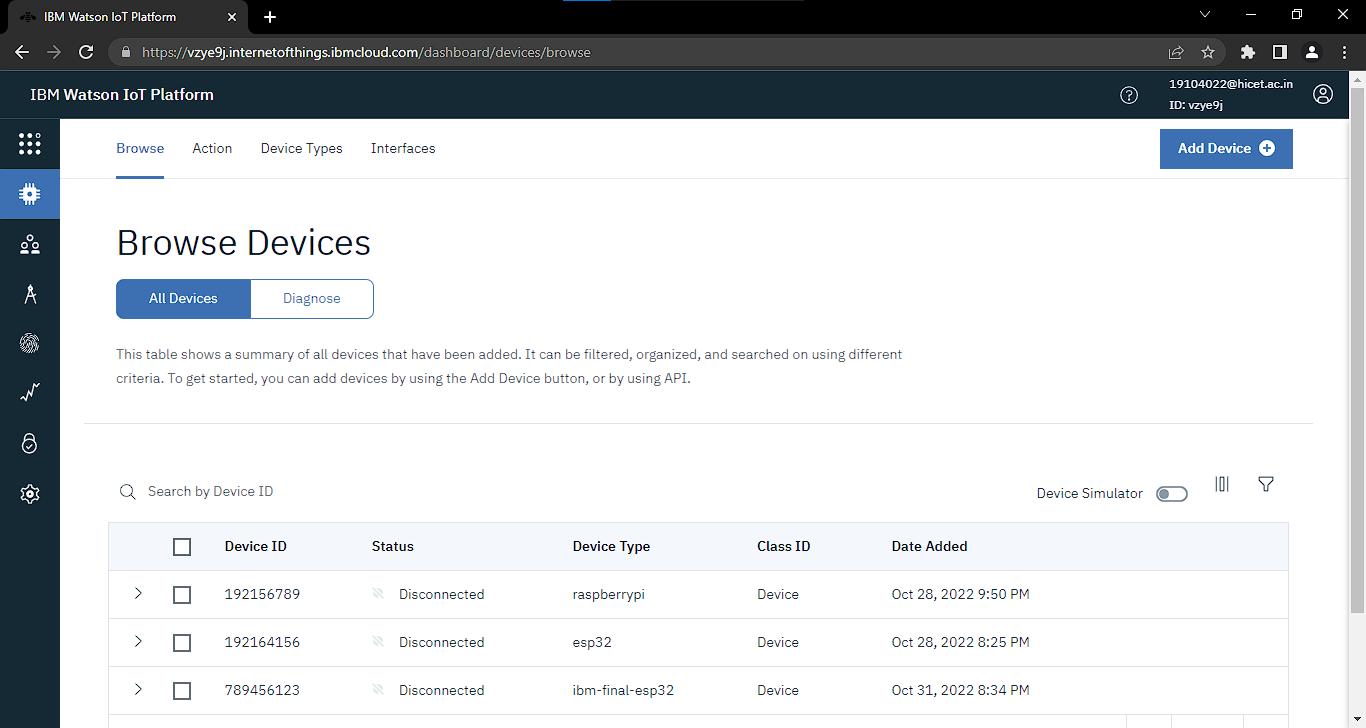
A burn down chart is a graphical representation of work left to do versus time. It is often used in agile [software development](https://www.visual-paradigm.com/scrum/what-is-agile-software-development/) methodologies such as [Scrum](https://www.visual-paradigm.com/scrum/scrum-in-3-minutes/). However, burn down charts can be applied to any project containing measurable progress over time.

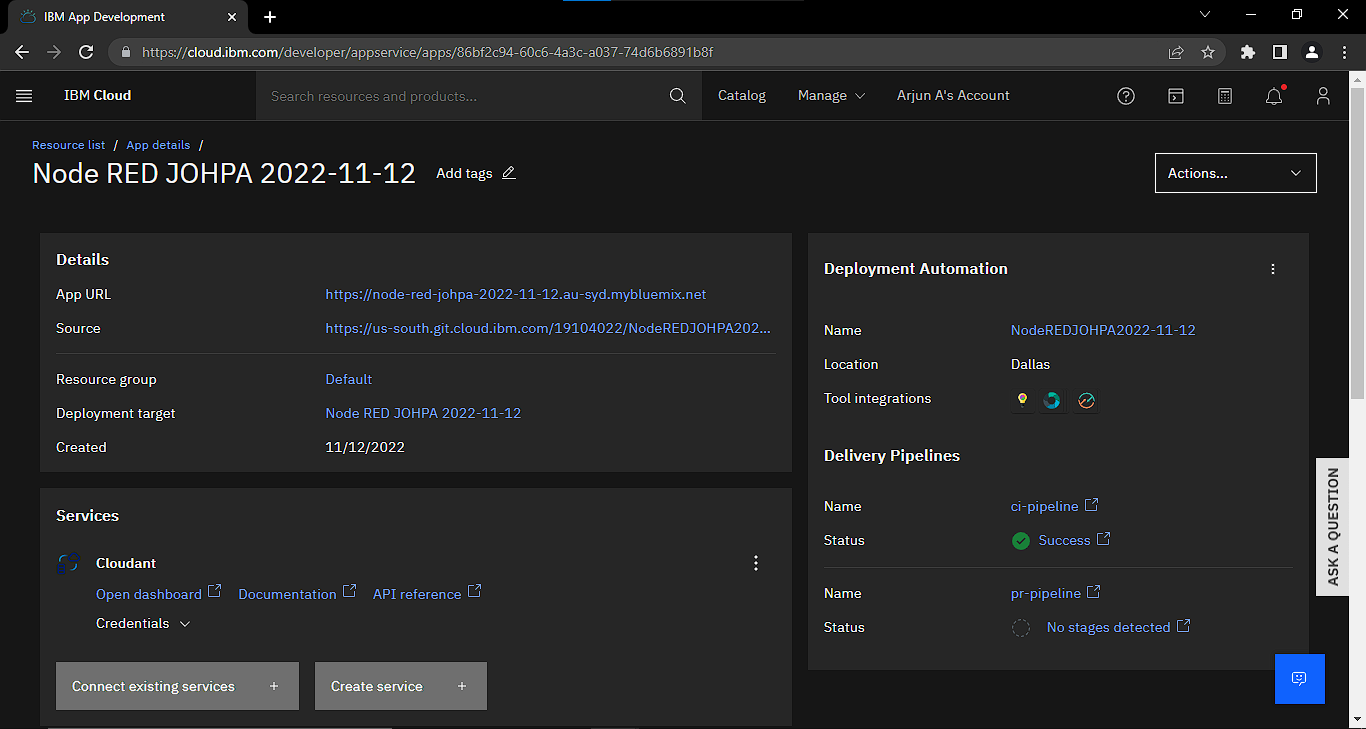


### CHAPTER 7 PROJECT DEVELOPMENT PHASE

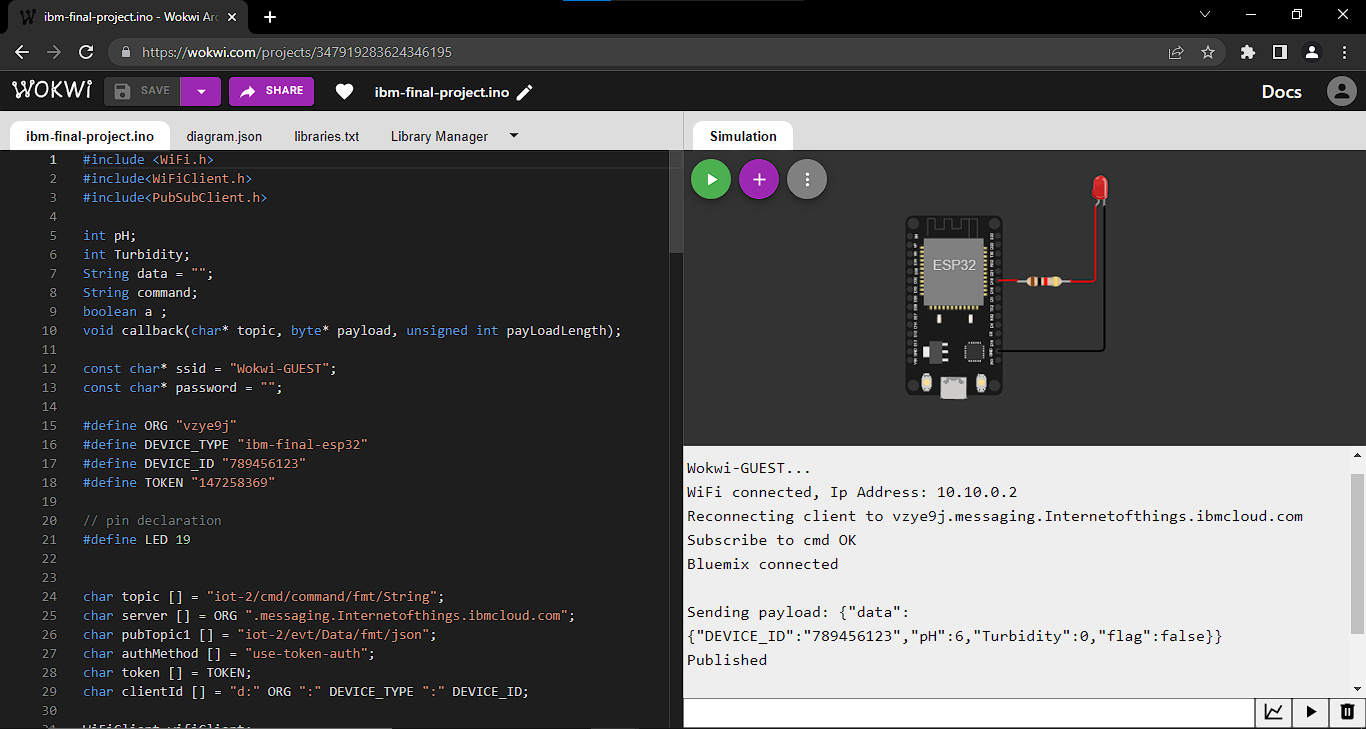
**7.1 Project Development - Delivery of Sprint – 1**

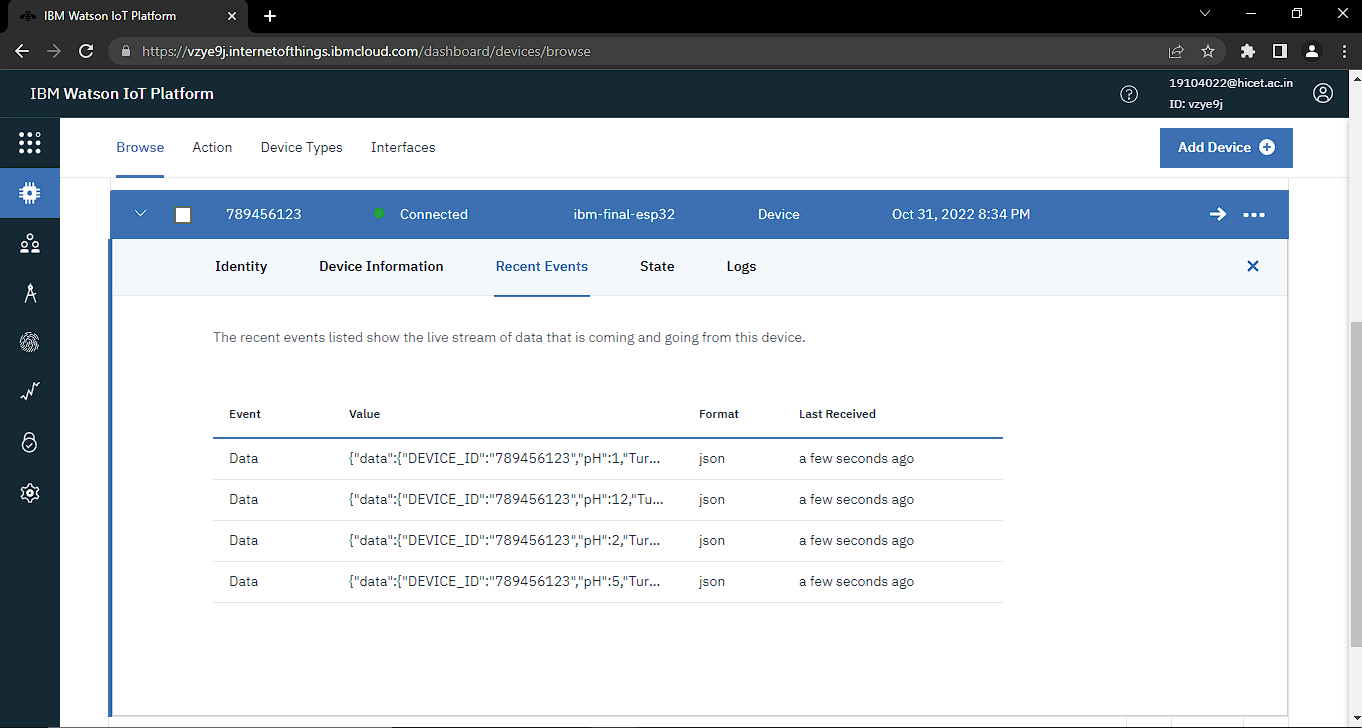
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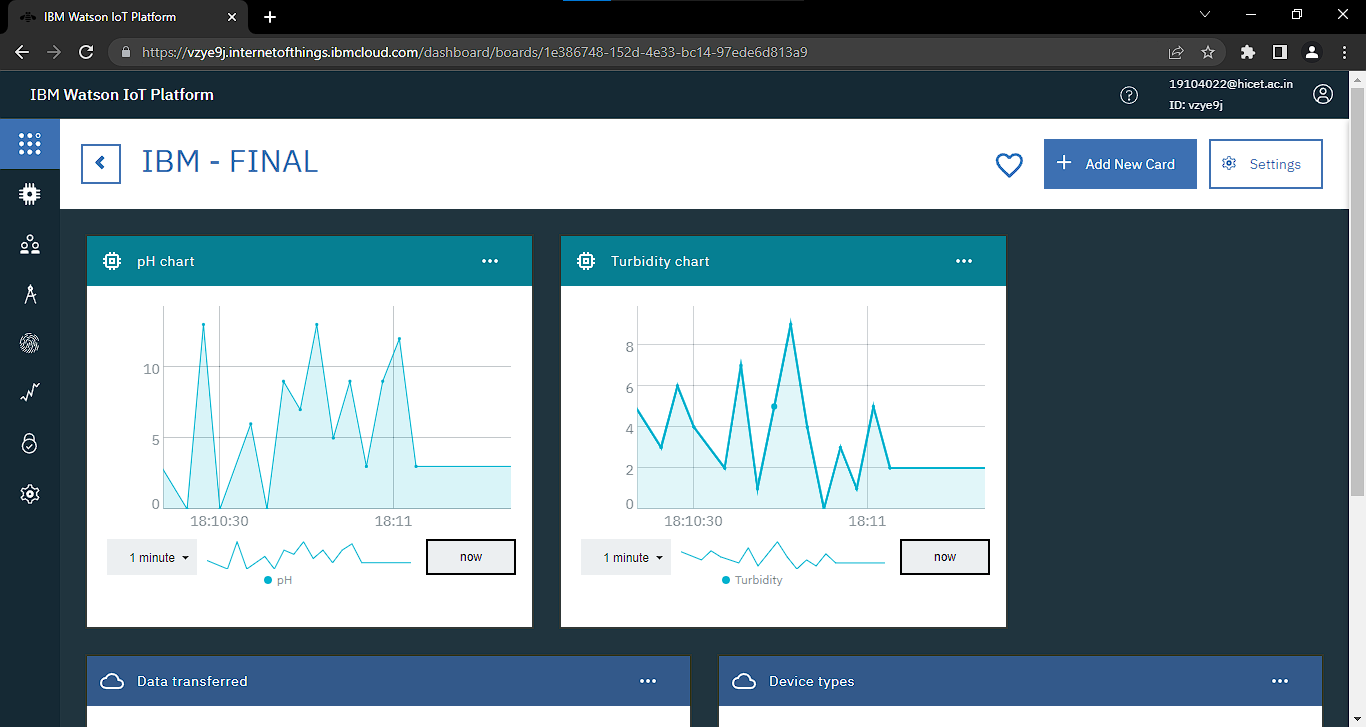
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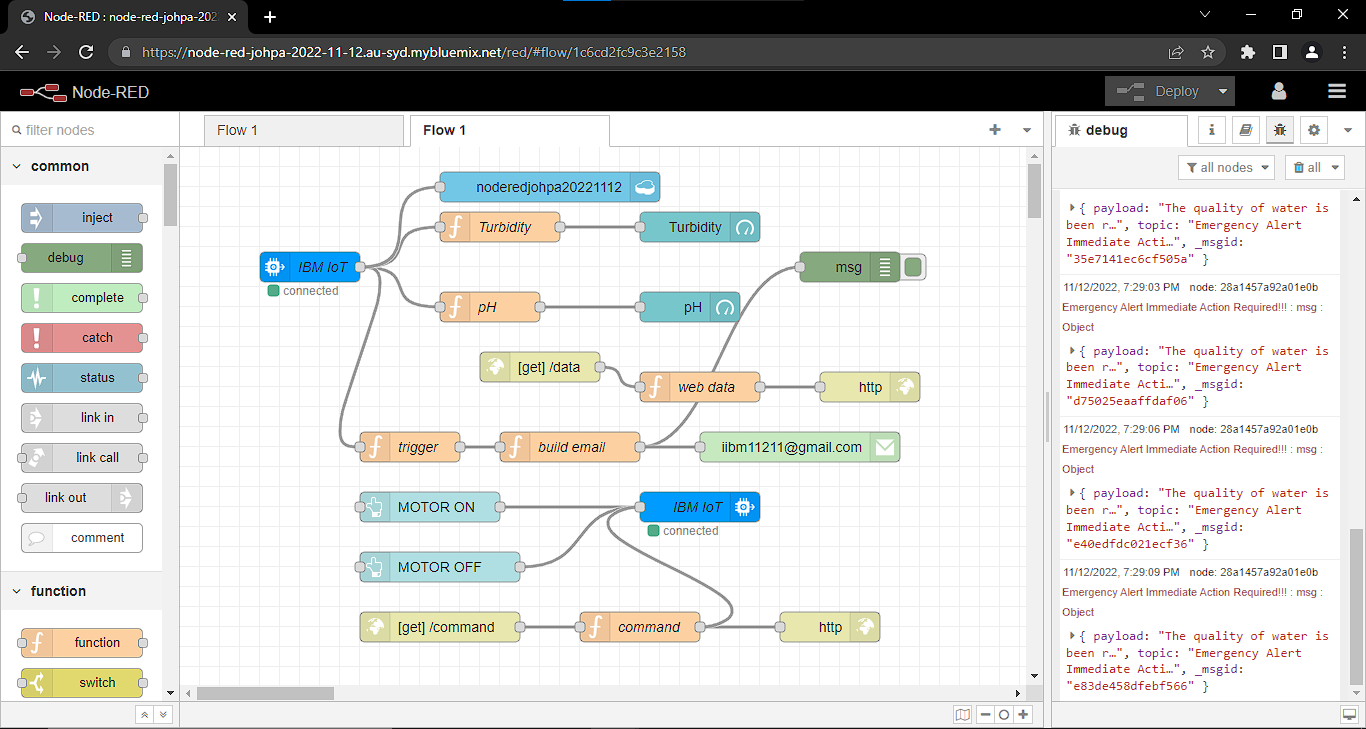
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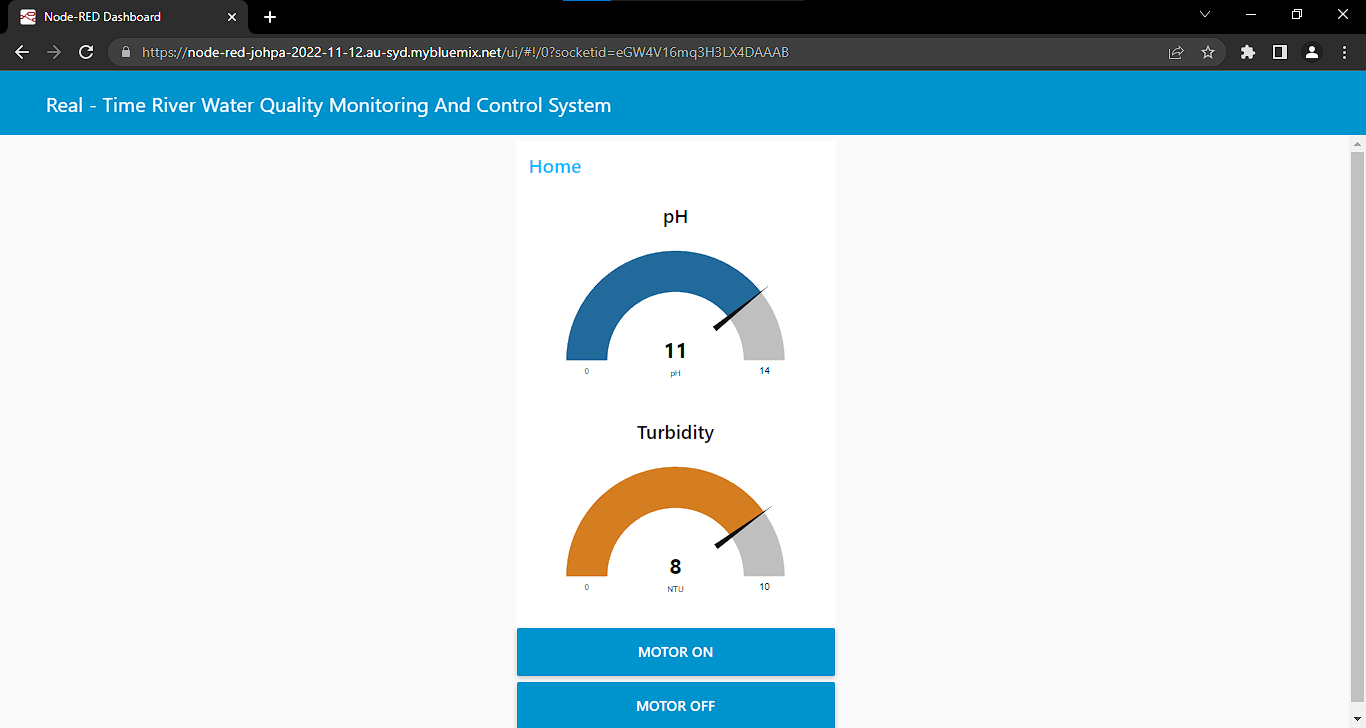
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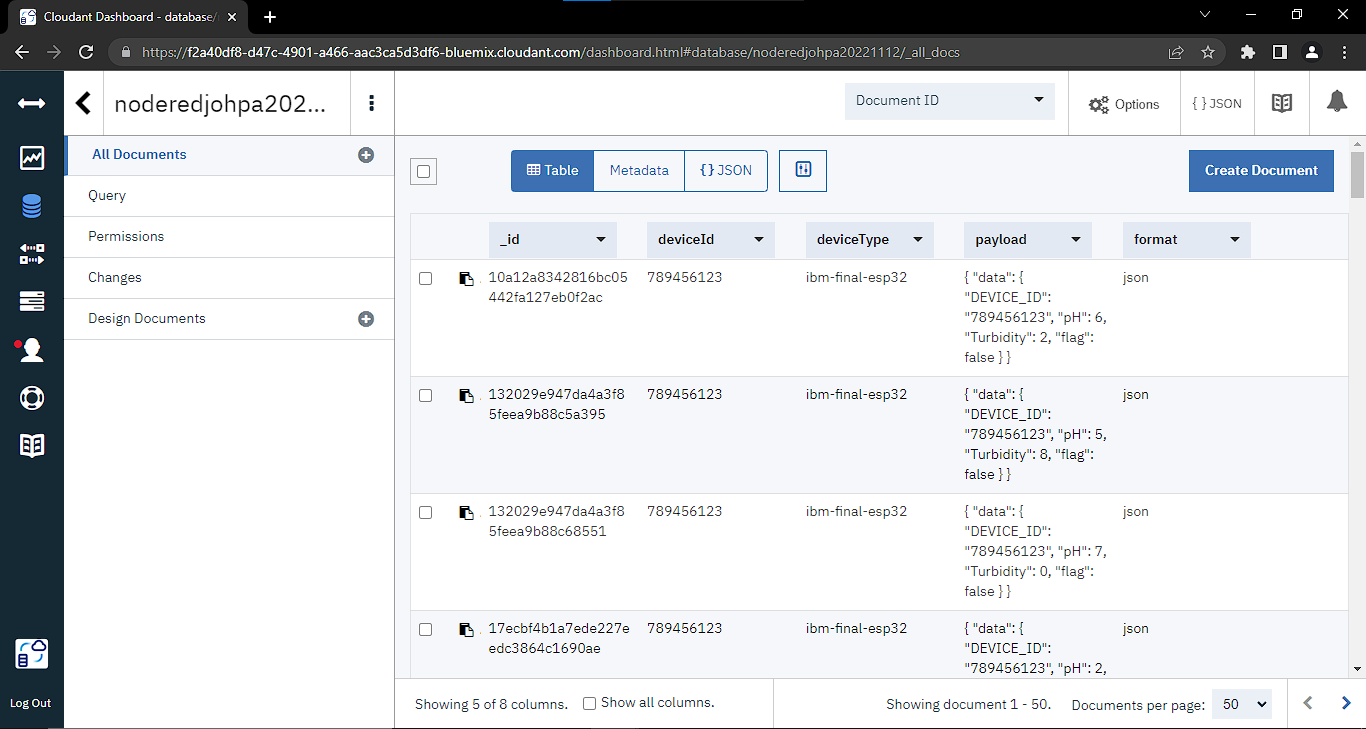
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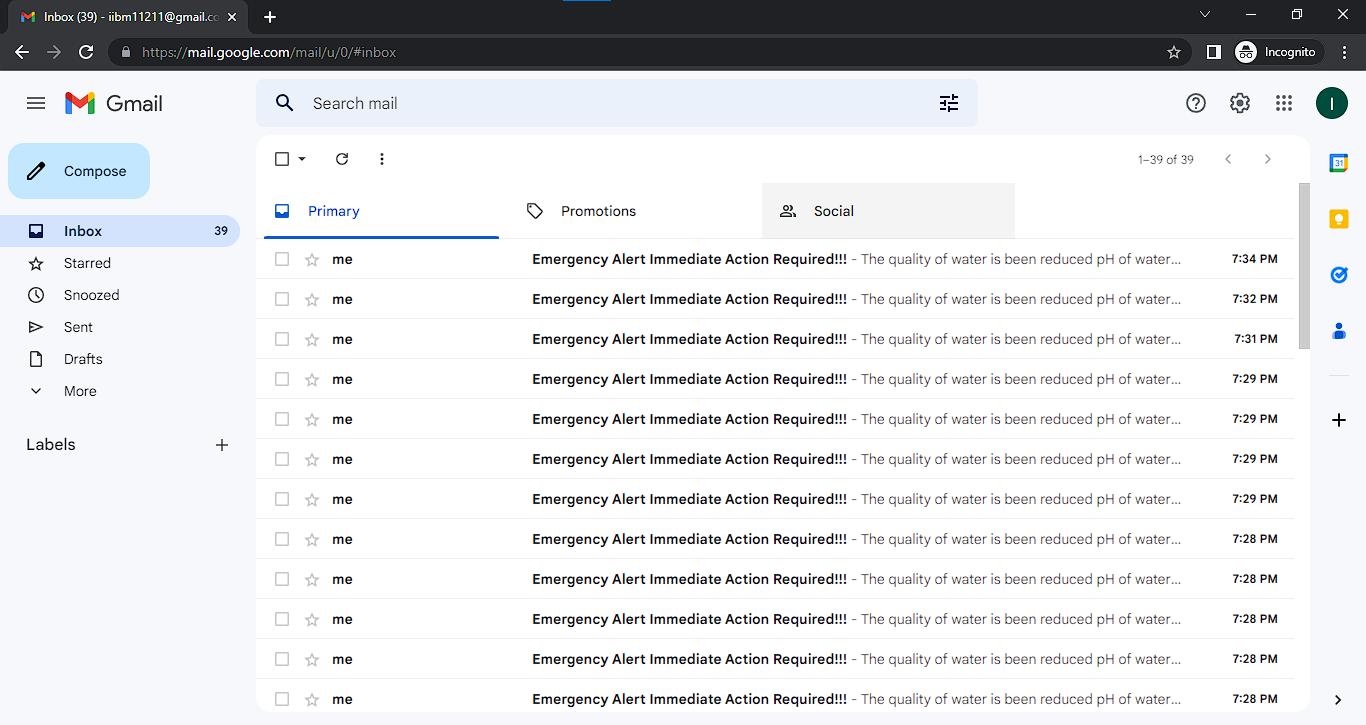


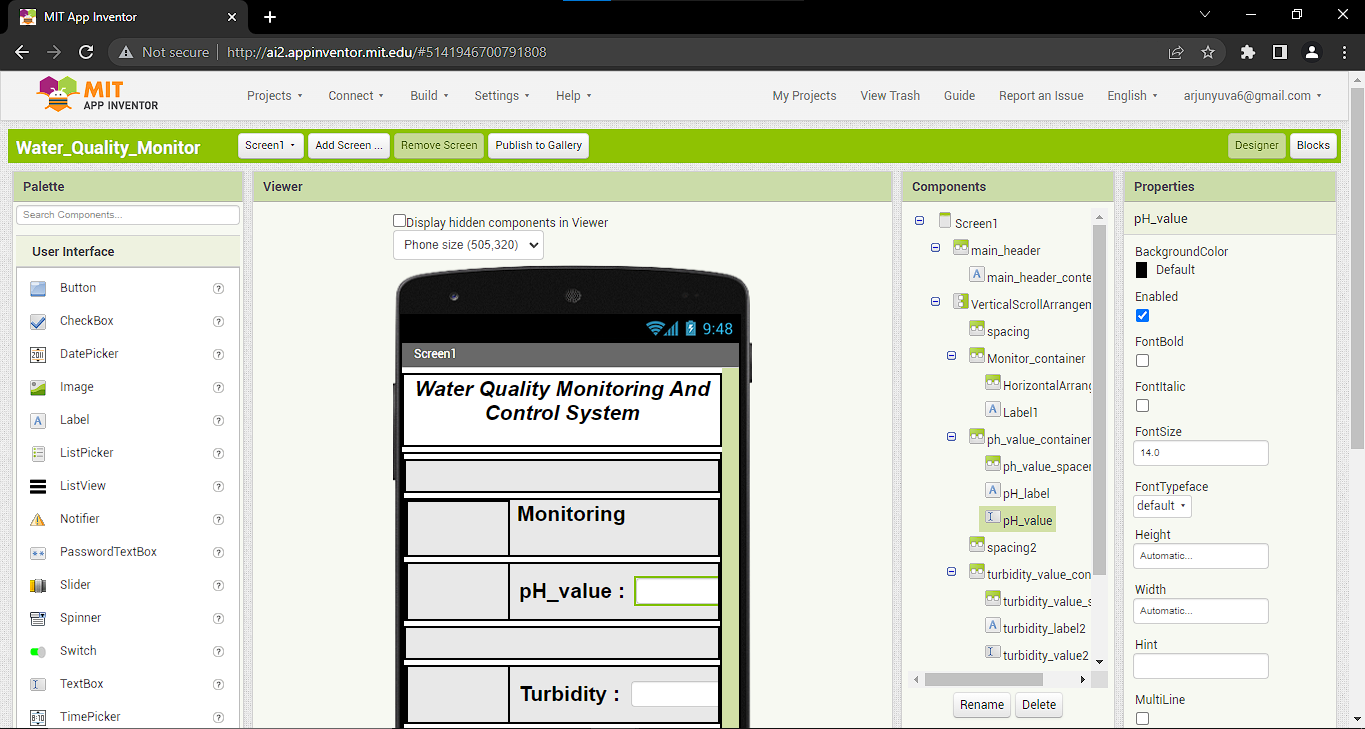
**7.3 Project Development - Delivery of Sprint – 3**

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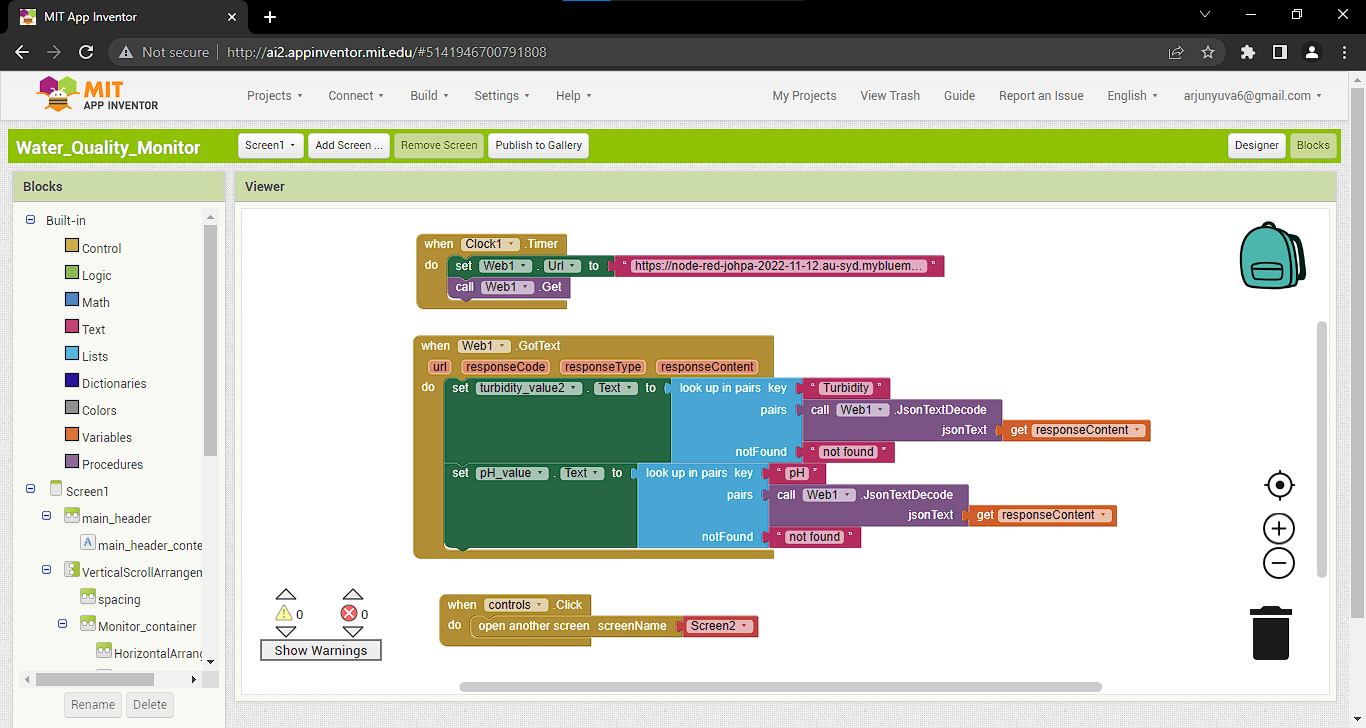


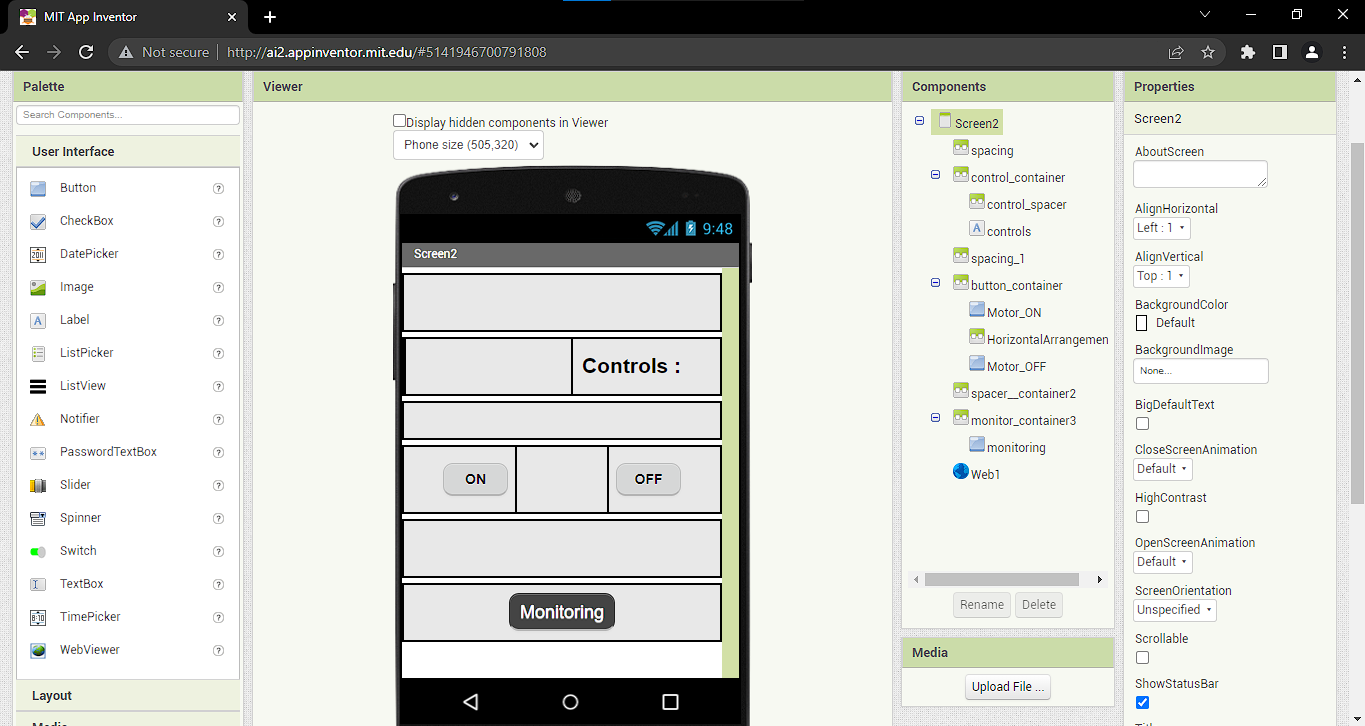


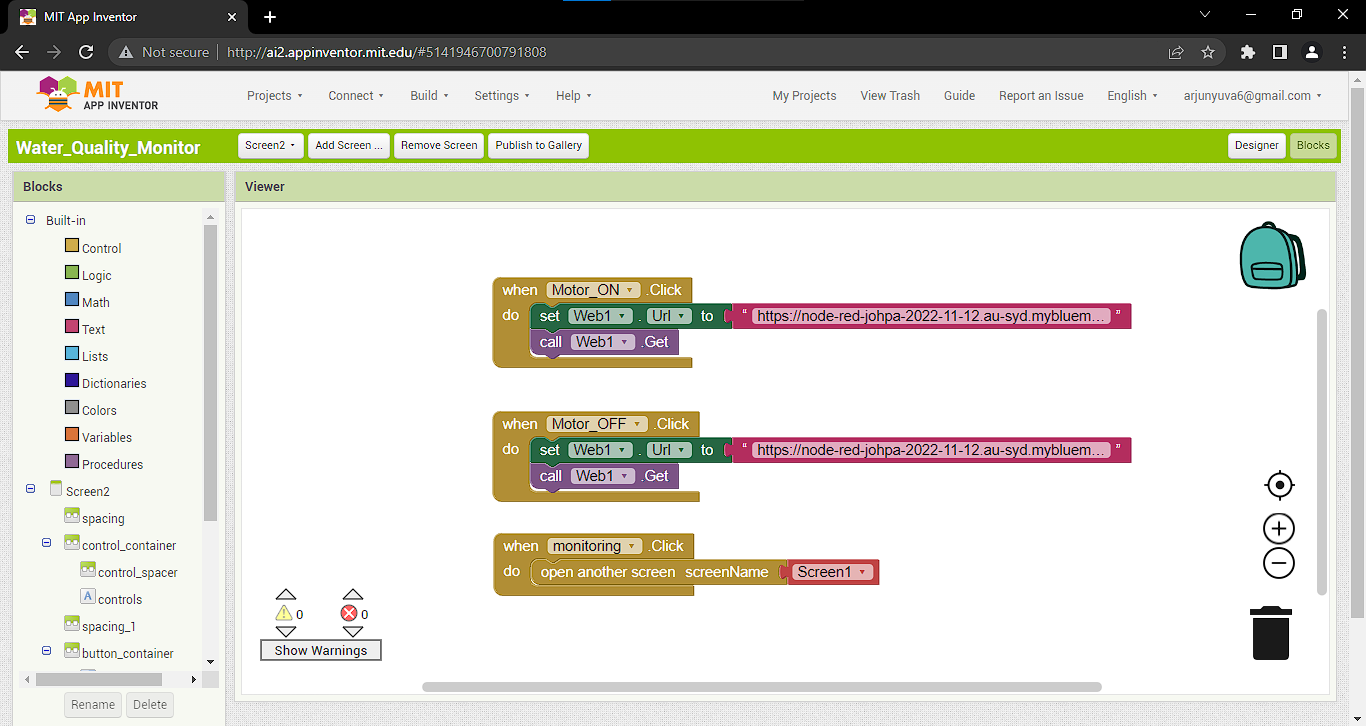


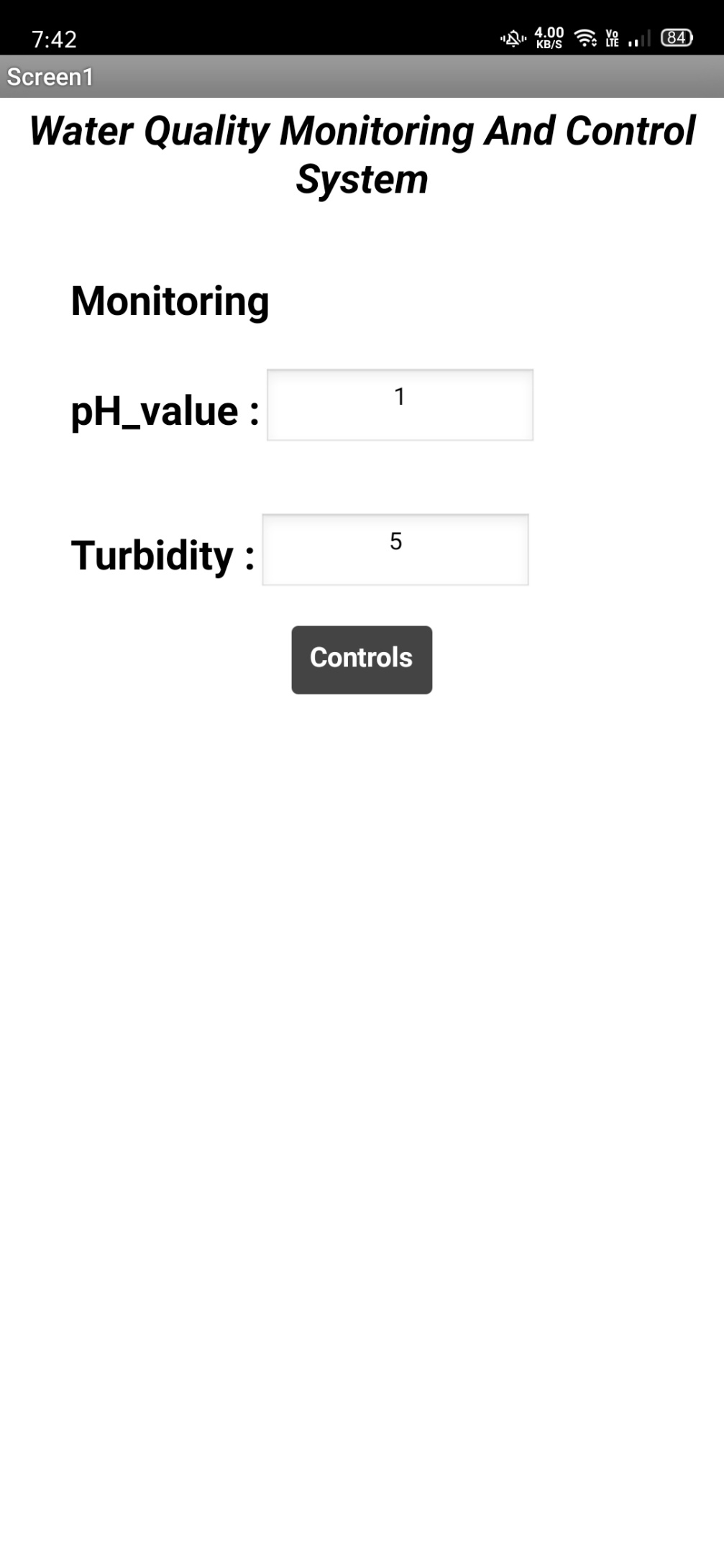


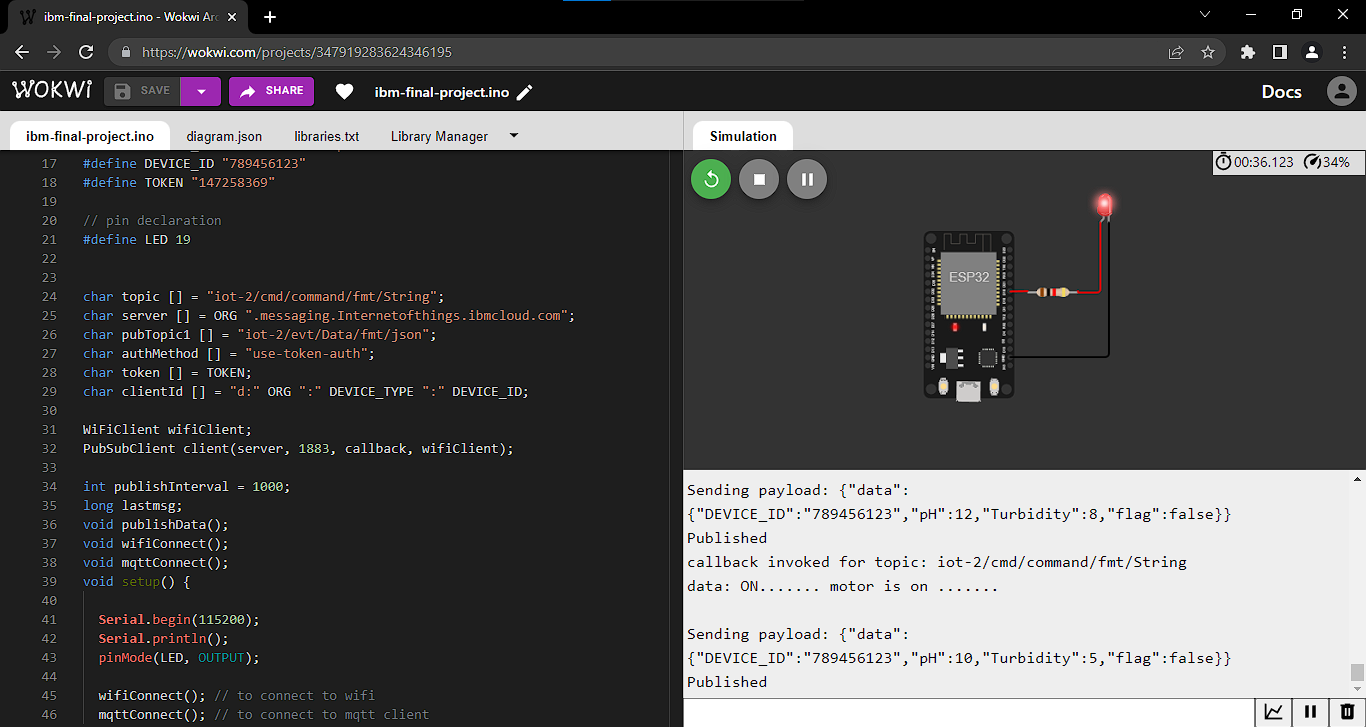
**7.4 Project Development - Delivery of Sprint – 4**

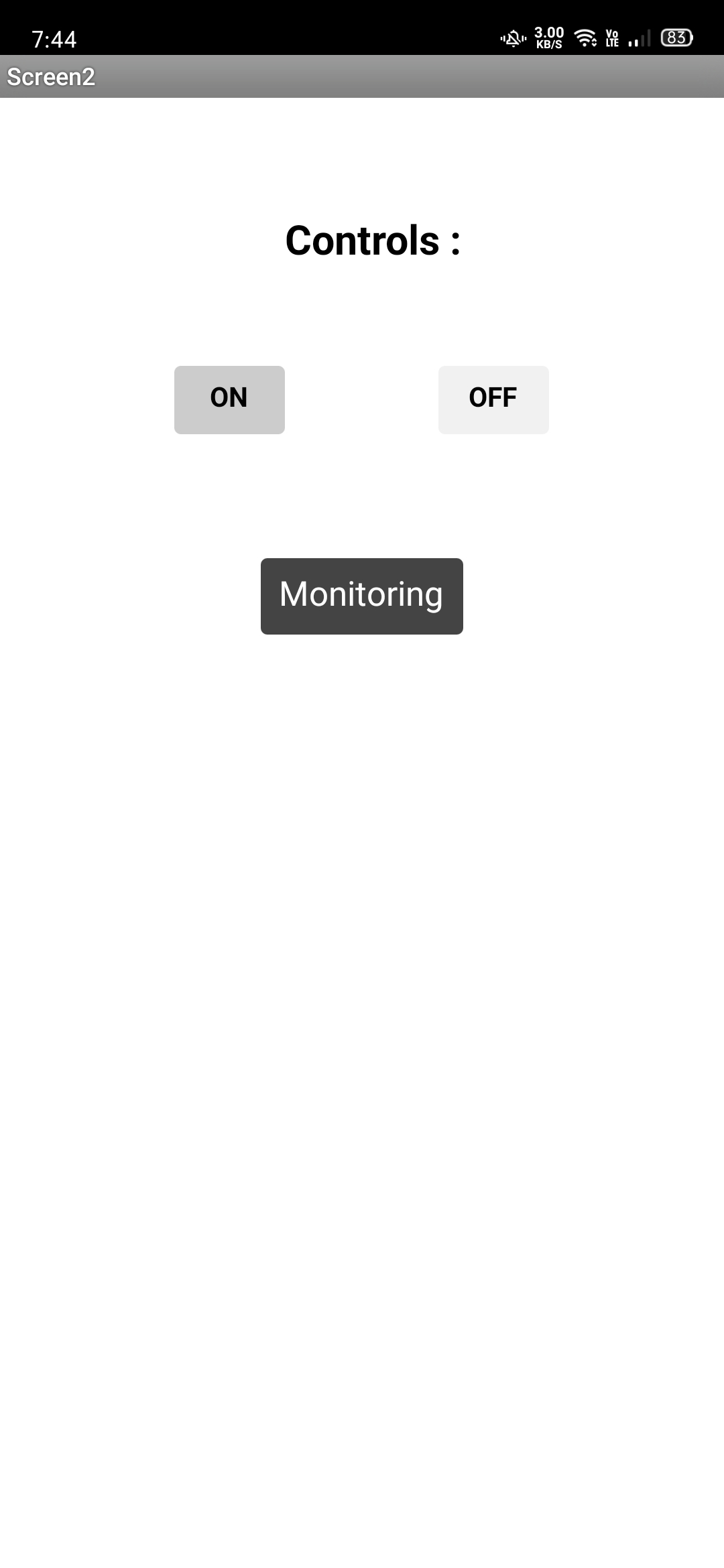
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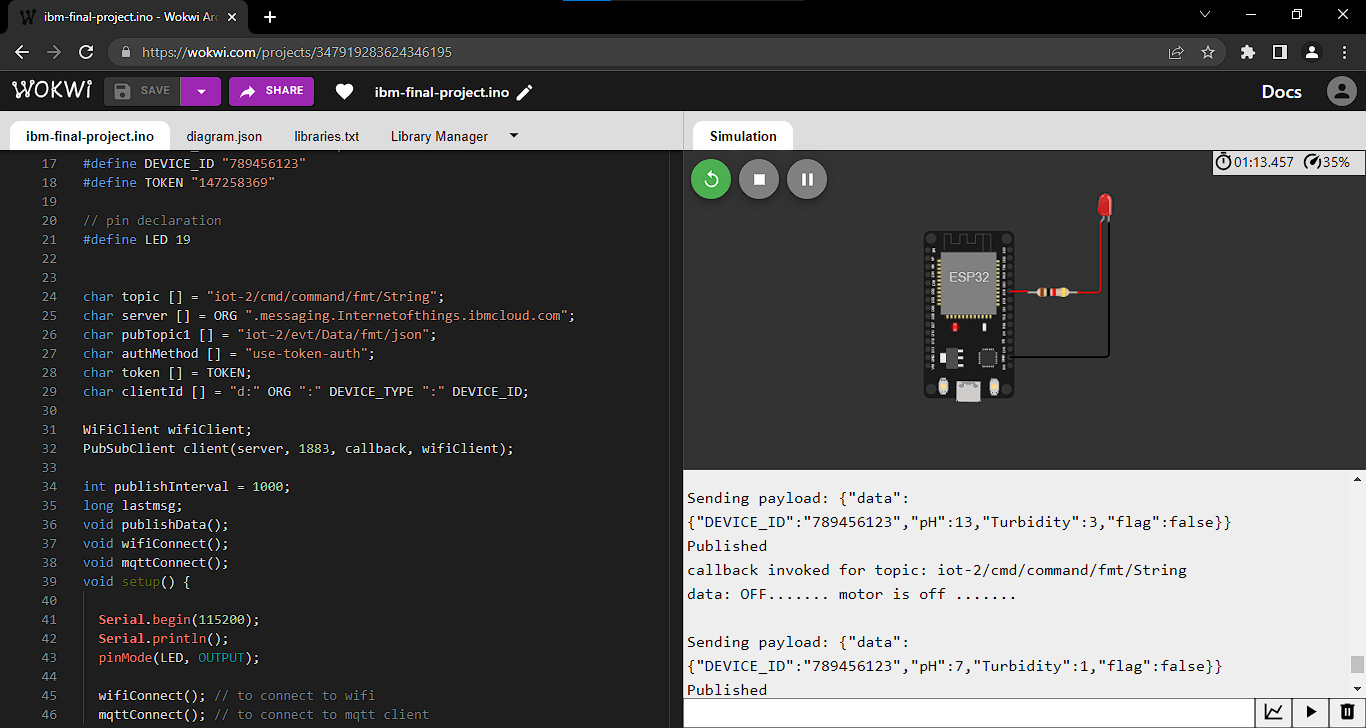
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**CONCLUSION**

Real-time monitoring of water quality by using IoT will immensely help people to become conscious against using contaminated water as well as to stop polluting the water. The research is conducted focusing on monitoring river water quality in real-time. Therefore, IoT is appeared to be a better solution as reliability, scalability, speed, and persistence can be provided.

IoT devices use various types of sensors to collect data about turbidity, ORP, temperature, pH, conductivity, etc. Of river water continuously. Also, IoT devices have capability to stream the array of collected data wirelessly to the remote Data Aggregator Server in the cloud. Moreover, the volume of semi structured data increases with time in such a velocity that only the Big Data Analytics applications can efficiently store and analyze the data constantly. Due to the limitation of the budget, we only focus on measuring the quality of river water parameters. This project can be extended into an efficient water management system of a local area. Moreover, other parameters which wasn’t the scope of this project such as total dissolved solid, chemical oxygen demand and dissolved oxygen can also be quantified. So the additional budget is required for further improvement of the overall system.

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