# Automatic detection and monitoring of water impurities in smart city

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### Abstract
*We present a novel and low-cost water quality monitoring system to diagnose the drinking water quality in municipal water distribution areas, where our system continuously monitors the drinking water which is ready to be distributed. This system ensures the quality of the drinking water before it reaches consumer sites. Initially, the quality of the drinking water is analyzed based on the parameters turbidity, temperature and conductivity.*

*After the measurement, these values are displayed in the embedded server which is an open server that could be viewed by any individual. The transparency is enabled among all the citizens by this method, thus ensuring their own safety. Nodes consisting of server network are placed at each distribution area and their quality is continuously monitored and updated in the server so that the necessary actions can be taken in advance. The embedded server is in a form of a web page, as and an android application. The viewing facilities are made flexible. Instead of displaying the analog values in the embedded server, they are replaced by 3 parameter – Safe, Moderate and Critical. Additionally, the analog values can also be obtained for further reference. The overall safety status of water quality is also displayed.*

**Keywords:** water quality monitoring, smart city.

## Introduction
All deliberate and unintended pollution are inherently prone to drinking water distribution systems. A contaminant may reachthe spreading system at many points. Conventional water quality control methods require manual processing of water samples at different locations and at different times, accompanied by laboratory analytical techniques to validate the tone of the water. These attacks are no longer regarded as successful. While the actual approach allows for a thorough analysis of chemical and biological agents, it has several disadvantages. Contaminated sources of water that contain traces of metals such as zinc (Zn), copper (Cu), nickel (Ni), lead (Pb), mercury (Hg), cobalt (Co) etc. and other major ions like), phosphate ($PO_4^{3-}$), nitrate (NO-3ammonium ($NH_4^+$) etc.

In this study, the sensor's electrical and magnetic fields will react with the metals and other major ions. Culture-based structured methods for detecting bacterial micro-organisms include traditional laboratory settings using bacterial surrogates or markers such as total coliform bacteria, fecal coliform bacteria, or Escherichia coli. Continuous on-line water tone monitoring with effective robust resolution is therefore clearly needed. The objective decision was to track many of the chemical and biological pollutants used in many water parameters including Oxidation Reduction Potential (ORP), Turbidity (TU), Ph and Electrical Conductivity (EC). Therefore, by analyzing changes in such parameters, it is possible to track and infer the water sound.

The purpose of this paper is to develop a low-cost device that can be used at consumers' prefaces to continuously track qualitative water parameters and fuse multi-parametric sensor output to assess the amount of water consumption. Contributions to the low-cost device are the design and production of low-cost networked embedded systems, as well as optical sensors (turbidity) for water tone monitoring, the development of event detection algorithms using fusion techniques, database evaluation and system performance evidence in different concentrations of polluted microbiologically (E.coli) and chemically (Arsenic) . The simple three sensors are used instead of using all the sensors to calculate the output parameters. They are the sensor for temperature, turbidity and conductivity. The observed analog values are converted into digital values using analog to digital converter (ADC). These values are collected to the Raspberry Pi 3 a mini computer. The Raspberry will calculate the values and displays them in an IOT embedded server using internet facilities.

In constant monitoring[7], the water quality is obtained through the several taps through a sensor and the sensor data is transmitted to the base station at 435 MHz with an RF module. This module mainly observes the temperature, PH and turbidity of the water. Reverse osmosis kind of water purification method is followed for further purification. In river water quality monitoring system[4], a wireless sensor node is installed in the system to monitor the pH value of the water.

The observed pH sensor value is sent to the base station through ZigBee communication. The sensor node in Wireless Sensor Network[8] based remote water quality measurement system usually enters into the sleep mode of operation when it is not collecting the data from the sensor node to reduce the power consumption. A portable phosphate value monitoring system[5] is designed for the natural water that includes multiple sensor networks to monitor water-temperature, phosphate, dissolved oxygen, conductivity, pH, turbidity and water level. A programmable system on chip (PSOC) with a multisensory network[6] for heterogeneous water quality measurement collects the magnitude of the sensors and processes the data to make it to a generic one. A thick film technology based multi-sensory network[1] for sensing oxygen reduction potential, temperature, pH, turbidity and conductivity was developed. But the whole system is fully coated with resin and can have direct contact with water for several sensing.

A river water quality monitoring system based on mobile agent enabled wireless sensor network[3] have installed. This system operates with a blend of edge technology such as an intelligent system, wireless network and mobile agents. Reliability, failover operations and scalability features are adopted in this mobile agent. Online monitoring of the water quality monitoring system is installed using GPRS[2] can monitor rivers, reservoir, swamps and deep and shallow groundwater areas in terms of the temperature, pH values.

## Material and Methods

**Materials:** The temperature sensor includes a thermistor whose resistance varies with respect to temperature. The observation of conductivity in aqueous solutions is significant to determine the impurities in water or to measure the dissolved chemical concentration.

Electrical conductivity meter finds the electrical conductivity of freshwater, aquaculture and in hydroponics systems. It monitors the number of impurities, salt and nutrients in the water. The purity of the liquid is calculated with respect to the observed temperature and conductivity.

Light-dependent resistor or photo-resistor or cadmium cell is a resistor. The resistance value of the photo-resistor decreases with respect to light incidence. Successive approximation type of 8-bit analog to digital converter circuit is used in the hardware for conversion and digital inputs to the raspberry pi board.

The method is to develop sensor nodes for real-time water quality management detecting both intentional and accidental contamination and displaying the status in the web page by using an embedded server. Additionally, the module sends mail to the authorities automatically. Firstly, the drinking water quality is analyzed based on the parameters of turbidity, temperature and conductivity. After the measurement, the values are being displayed in the embedded server which is an open server and can be viewed by any individual by whom the transparency is enabled among all citizens to ensure their own safety.

Initially, the node is set up in different water treatment or distribution areas. The water quality is measured through the sensors in the still water. The important parameters of drinking water standards are checked using 3 sensors namely turbidity, temperature and conductivity. These digital values are analyzed and sent to the ADC converter and provide the digital input to the Raspberry Pi. The internet is enabled in the raspberry pi through the Wi-Fi dongles. The Raspberry Pi analyses the value and displays the values in the web page through an IOT embedded server.

Additionally, when the water quality parameters go very low in a particular region, the Raspberry Pi device generates mail to the respective authority for precautionary measures. Figure 1 depicts the block diagram of the proposed system and works as a single module. Figure 2 represents the overall model of the proposed system. The quality ranges of the various sensors are listed in table 1.

**Table 1**
**The quality ranges of the various sensors**

| Parameters | Measurement Principle | Units | Range | Resolution | Accuracy | Quality Range |
|---|---|---|---|---|---|---|
| Turbidity | Optical/Infrared scattering | NTU | 0~100 | 0.1 | ±0.5 | 0-5 |
| ORP | Galvanic cell, platinum electrode | mV | -2000-2000 | 2 | ±10 | 600-800 |
| pH | Galvanic cell, glass electrode | pH | 0-14 | 0.05 | ±0.1 | 6.5-8.5 |
| Conductivity | Conductive cell | μS/cm | 100-20000 | 10 | 5% | 500-1000 |
| Conductivity | Inductive cell | μS/cm | 200-3000 | 10 | 5% | 500-1000 |
| Temperature | RTD resistance | ºC | -5-100 | 0.1 | ±0.1 | - |
| Flow | Magnetic rotor, hall effect sensor | L/min | 1-115 | 0.0015 | 15% | - |

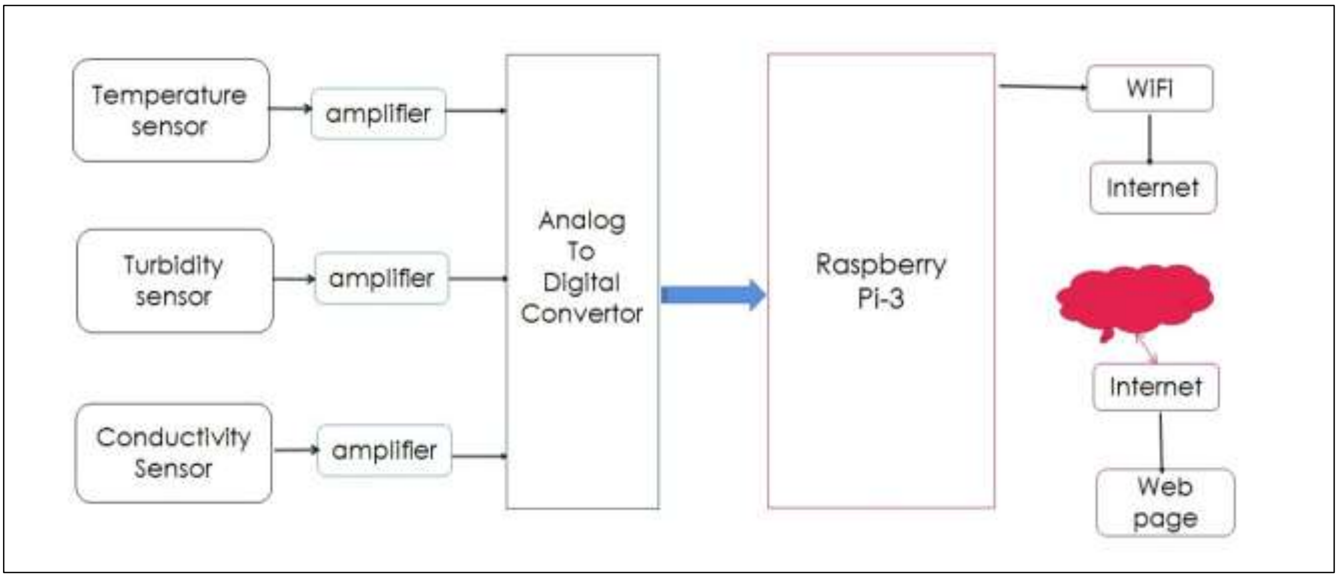


**Figure 1: Block diagram of Single unit**

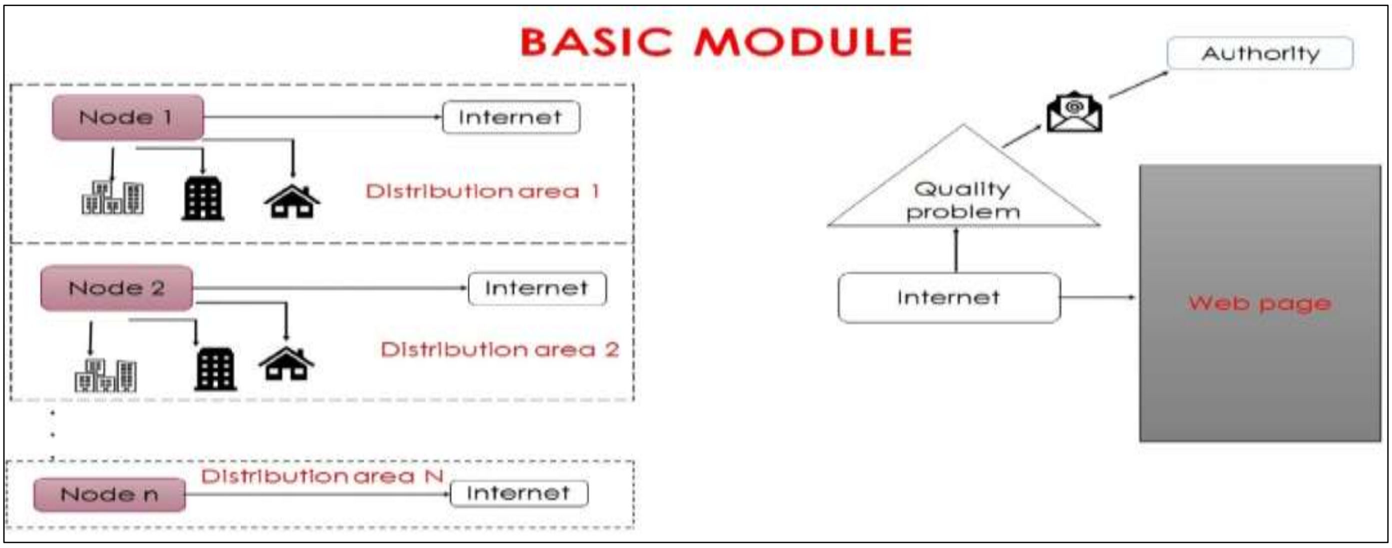


**Figure 2: Block diagram of the whole system**

**Software specifications:** Python features as dynamic and automatic memory management. This supports multiple programming paradigms like object-oriented, imperative, functional and procedural paradigms and has a broad and detailed standard library. Python is open source software with a community-based model of development, as do almost all of its implementations. With remot3 weaved login remot3, you can easily connect to networked devices using HTTP(S), VNC, SSH, or any TCP connection. It uses secure cloud architecture to ensure that it can get to our networked devices.

There is support for a growing list of devices including Raspberry Pi, Virtual Machines, Cellular Routers, embedded systems based on ARM, MIPS and x86. The SSH (file transfer remote console) option constructs remot3.it to link the port 22 with your favorite SSH client. Simple SSH login to remot3_it will give an IP address: the port combination that you can copy and paste to SSH client to link. A stand-alone SSH client application such as PuTTY, or command-line scripts, depending upon the Operating System is used. Open Sprinkler that uses the controls using a web interface. This choice for port 80 is pre-configured.

## Results and Discussion

The system developed is shown in figure 3 and it was tested with various types of water and the outputs displayed on webpage are noted in the table 2. The simulated web page output through cloud is displayed in figure 4. The critical stage of the distributed water to the houses is found with contamination of salt and turbidity is alerted to the city municipal is shown in figure 5. The level of turbidity and salt contamination was updated to the web in figure 6-7. Figure 7 shows that the system was experimented for the water tank which was used in houses and its details are observed. Table 3 present the observed results of our proposed system with various levels of contamination which has introduced in the water.

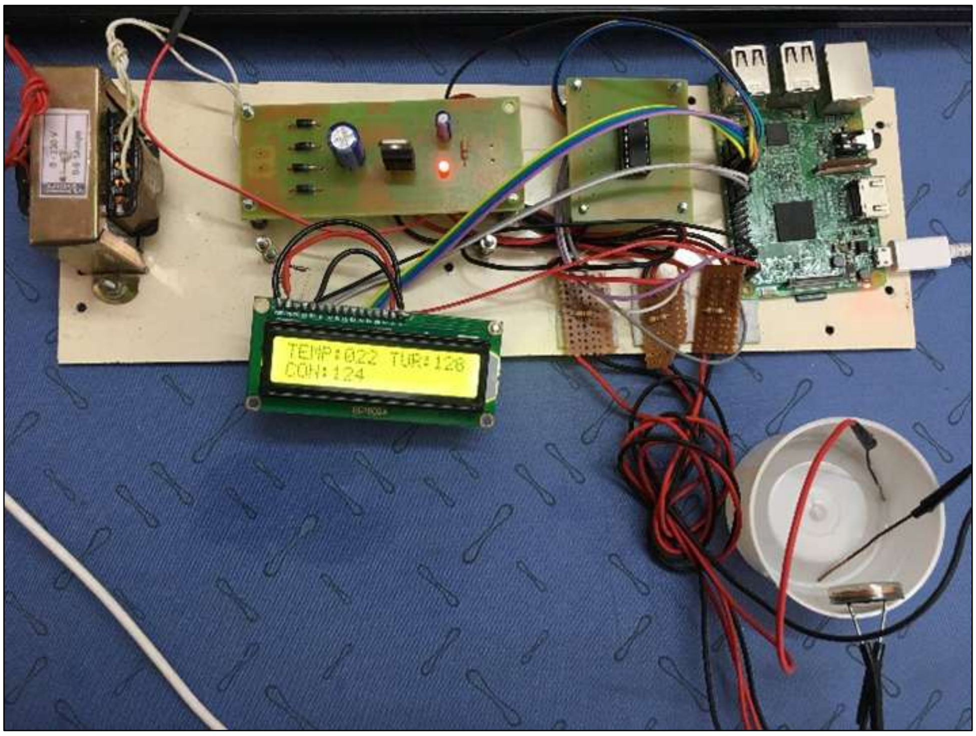


**Figure 3: Hardware of proposed system**

**Table 2**
**Results for various types of water observed from the installed hardware**

| Type of water | Temp | Turbidity | Conductivity | Status | | |
|---|---|---|---|---|---|---|
| | | | | Temp | Turbidity | Conductivity |
| Normal water | 23 | 33 | 9 | Safe mode | Safe mode | Safe mode |
| Contaminated Water | 29 | 35 | 142 | Safe mode | Critical mode | Critical mode |
| Salt water | 28 | 179 | 190 | Safe mode | Safe mode | Critical mode |
| Well water (drinking) | 21 | 91 | 46 | Safe mode | Safe mode | Safe mode |

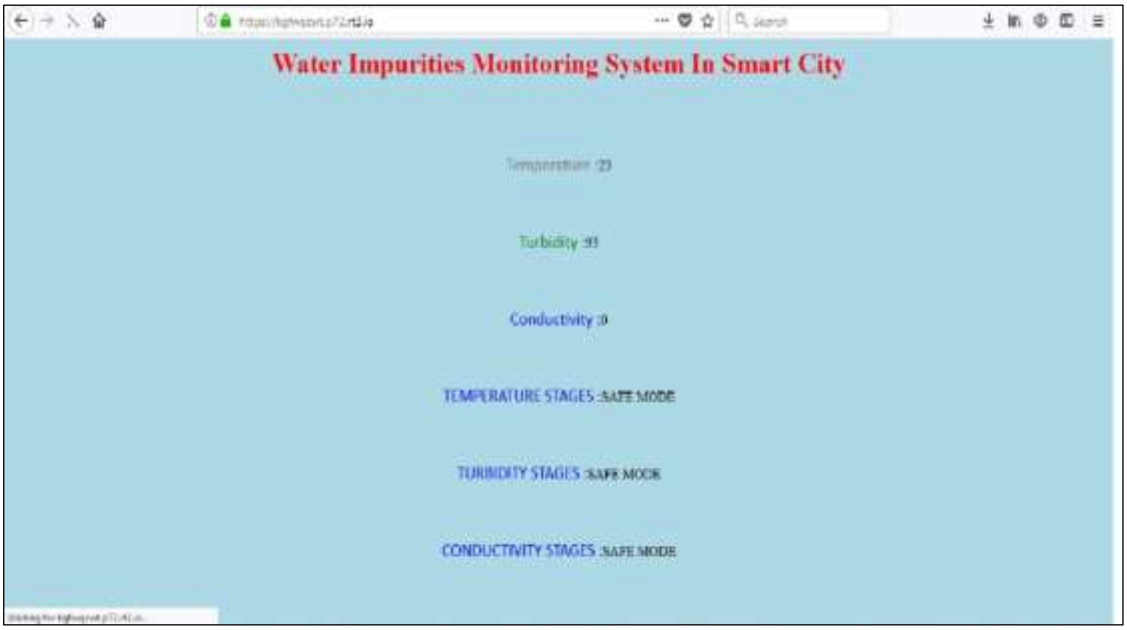


**Figure 4: Webpage output**


**Figure 5: Automatic mail on critical mode**

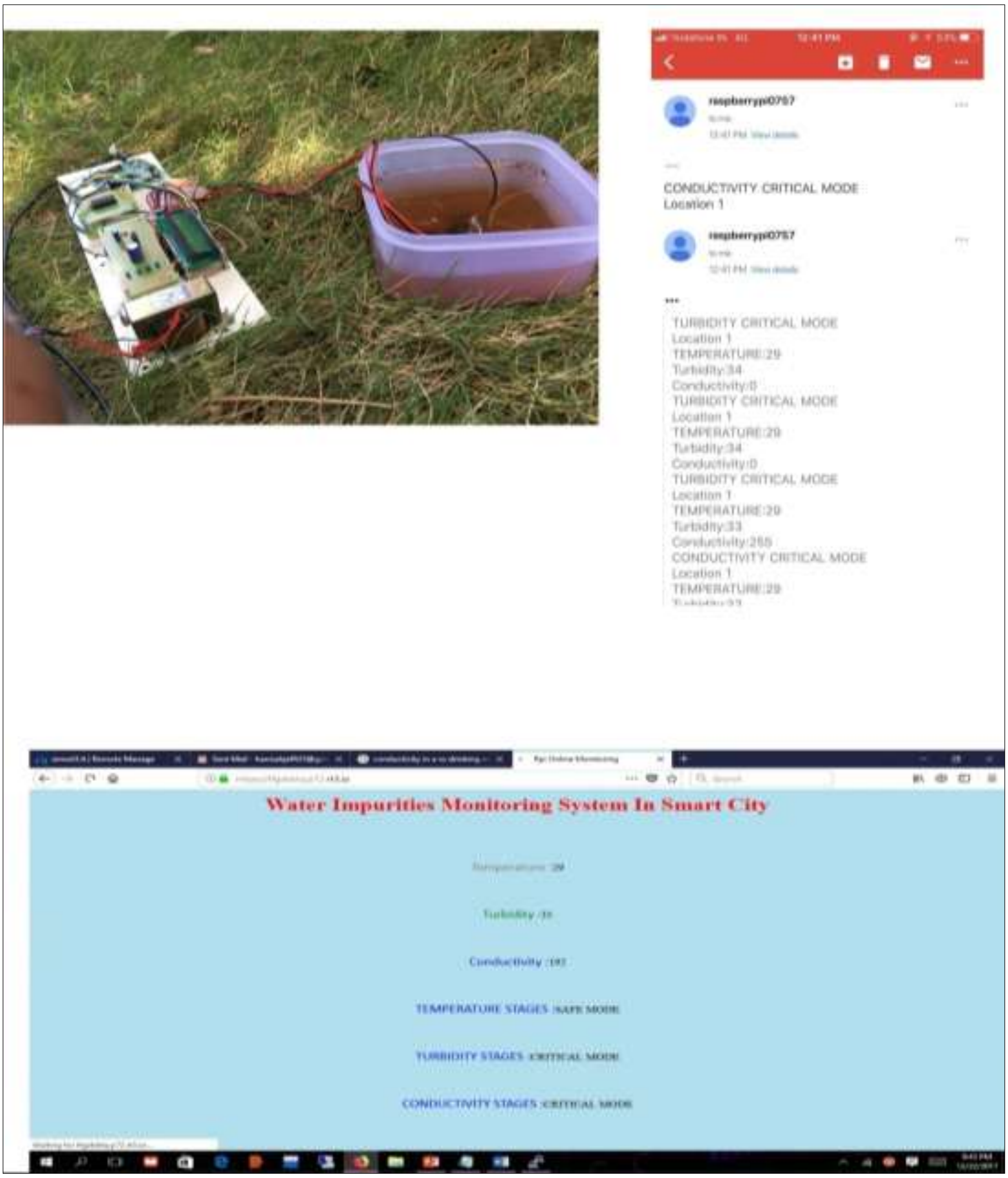


**Figure 6: Practical Application in Contaminated Water**

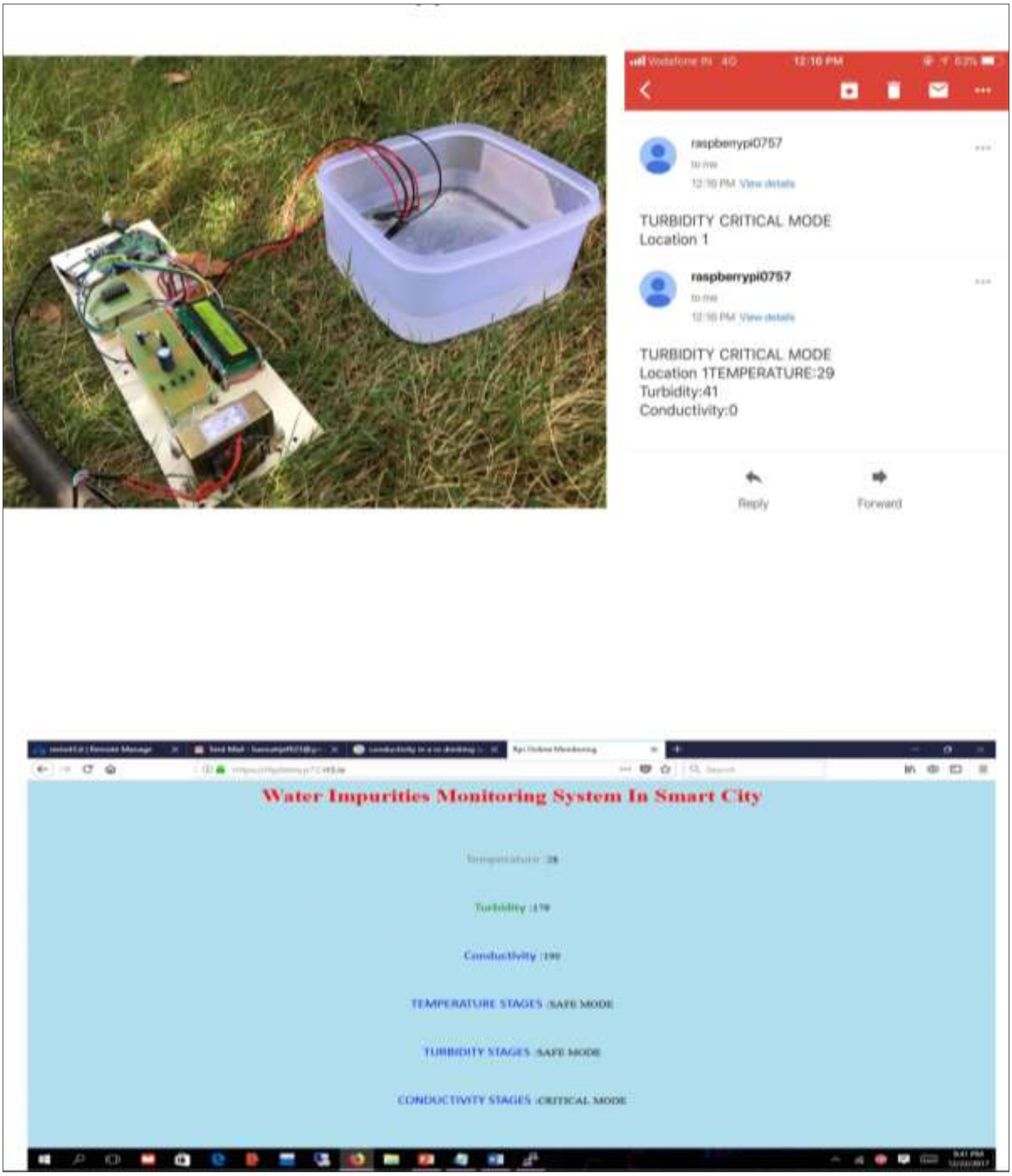


**Figure 7: Practical Application in Salt Water**

**Table 3**
**Monitored results with the inducement of contaminants as salt**

| Quantity of contaminants in mg | pH | Conductivity µs/cm | Turbidity |
|---|---|---|---|
| 4 | 6.7 | 418 | 5 |
| 8 | 7.2 | 348 | 6 |
| 12 | 7.9 | 427 | 5 |
| 16 | 8.0 | 570 | 7 |
| 20 | 7.9 | 764 | 7 |
| 24 | 8.1 | 863 | 8 |
| 28 | 8.4 | 969 | 9 |


**Figure 8: Practical Application in Drinking Water**

## Conclusion

This proposed system provides installing the system in several locations of the water distribution network to collect spatiotemporally rich water quality data and characterize system/sensors response in real field deployments by thus making it a smart city.

A low cost, less complex water monitoring systems was developed and it can be installed in various houses and monitored through the municipality. Then the corporation can take the decision to maintain good quality of water to be distributed to the common people to live their health life. This module will have a plan to make the city very smarter for water distribution.

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