Development of Water Quality Monitoring Device Using Arduino UNO

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Abstract. Regular water quality monitoring of water bodies is essential to ensure it is within the allowing standard limits. The development of a simple and low-cost water quality measurement device for real time monitoring using Internet of Things (IoT) technology is presented in this study. Kolora meter is an alternative to the existing commercial monitoring devices. It was developed using the open-source platform Arduino UNO model and NodeMCU board as the microcontroller and Wi-Fi connection respectively. Two sensors such as temperature and turbidity were selected to be installed in the early stage of Kolora meter development. The physical parameters (temperature and turbidity) of water were measured and the measured data collected are able to be viewed and monitored on the mobile phone using Kolora Mobile Application via Wi-Fi connection. Therefore, this surface water quality device has potential to be applied in real time monitoring for early pollution detection and during COVID-19 pandemic spread due to limited movement.

1. Methodology
About 1% water resources such as river, lake and ocean are utilized as water supply, irrigation and recreation for human activities. The increase of population causes these water resources polluted with rubbish, toxic wastes, agriculture fertilizer and others. The physical, chemical and biological properties of the water resources should be regularly monitored to ensure they are safe to be used. Therefore, it is important to have an efficient water quality monitoring system to monitor the water quality in a particular area.

The water monitoring activities need to be carried out periodically to minimise the exposure of pollution to community and aquatic life. The traditional methods of water quality monitor involve manual collections of water samples from different locations. Typical water quality monitoring technologies are lack of integration, involve labour-intensive, long time to set up and expensive [1]. The size is large and may be difficult for transportation especially for isolated and broad monitoring areas. Furthermore, the operation of the instrument needs to be carried out by an experienced user.

The application of Internet of Things (IoT) concept brings new inventions in society such as the Radio-Frequency Identification (RFID), smart home, smart device, sensors and mobile phones. These technologies can be integrated among the device components to produce the desired product [2]. The integration of IoT and water quality monitoring system is viable and has shown promising products [3]. Daigavane and Gaikwad [4] has successfully developed a low-cost system for real monitoring system ATMega 328 with Wi-Fi module [4]. It enhances the detection system of the polluted water and helps to eliminate some drawbacks of the older version systems. This shows that the
implementation of the IoT in the water quality monitoring system brings a huge advantage to the smart environmental monitoring field.

Arduino is an open-source software system that can be used to developed desired devices easily [5]. Since the Arduino microcontroller is an open-source software, thus, it is easily to be accessed and significantly reduces the developed device cost. It is also recognized as an effective approach used by the researchers to manage and control the test apparatus via an automated mechanism [6 – 7]. Cruz et al. [8] developed an automated online monitoring system to control parameters variables (pH, temperature) of an anaerobic digestion process for biogas production as an alternative to higher monitoring cost equipment, decreasing management costs. This system assisted in the performance anaerobic digestion process to improve biogas production [8].

In this study, the application of Arduino platform, sensors, Liquid Crystal Display (LCD) and NodeMCU ESP8266 to develop water quality monitoring device (Kolora meter) with better features and lower price is presented. The NodeMCU ESP8266 was installed to connect the device with the Blynk App for real-time data transfer via Wi-Fi connection. The validation of temperature and turbidity data for performance stability and consistency of the device was carried out by testing the device in different conditions of water quality.

2. Methodology

2.1. Device Setup
The general block diagram for Kolora meter development is shown in figure 1. This block diagram explains the system architecture of Kolora meter. Figure 2 shows the overall hardware parts including breadboard, DS18B20 temperature sensor module, SEN0189 turbidity sensor module, LCD and NodeMCU ESP8266 board installed on the Arduino UNO board for Kolora meter.

![Figure 1. The block diagram for the development of Kolora.](image1)

![Figure 2. The wiring profile of the Kolora.](image2)
The Arduino UNO microcontroller was programmed using C++ programming. The coding was programmed in Arduino App Version 1.8.5. To install each sensor module in the Arduino UNO system, a specific library was required to enable the coding of specific sensor to function. The sensor module is summarized in Table 1. The coding begins with the declaration of the library name and the values. Then the pin was assigned and used for Kolora meter. Finally, the looping of the coding command was assigned.

### Table 1. Formatting sections, subsections and subsubsections.

| Module                              | Library Name                                                                 |
|-------------------------------------|-----------------------------------------------------------------------------|
| NodeMCU ESP8266                     | https://create.arduino.cc/projecthub/pawan-kumar3/serial-communication-between-nodemcu-and-arduino-640819 |
| LCD1602 LCD Module                  | https://github.com/fdebrabander/Arduino-LiquidCrystal-I2C-library           |
| DS18B20 Temperature Sensor Module    | https://github.com/tomdeboer/SparkCoreDallasTemperature                      |
| SEN0189 Turbidity Sensor Module     | https://wiki.dfrobot.com/Turbidity_sensor_SKU__SEN0189                      |

#### 2.2. Calibration Procedure

**Turbidity.**

The turbidity sensor used in this study was the SEN0189. It measured turbidity in water by transmitting the light source from infrared LED towards infrared phototransistor. The infrared phototransistor detects the amount of light that passes through the turbid water and then automatically changes its resistance and voltage value. The signals received and processed by Arduino microcontroller and displayed on the LCD screen [9].

The turbidity calibration was done by diluting different amount of flour from 1 to 5 g/L in water, which acts as suspended solids. The total suspended solids (g/L) of these solutions were determined. The turbidity SEN 0189 probe was immersed in different concentrations of the mixed solutions to obtain the turbidity and voltage values. The relationship of total suspended solids (g/L) and turbidity (NTU) in water was determined based on equation (1) [9]. This equation was used as a reference to calibrate our turbidity sensor (SEN0189) to provide accurate readings. The distilled water was used as the blank.

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Turbidity \text{ of water (NTU)} = 1.873 + (0.518 \times \text{Total Suspended Solids (mg/L)}) \tag{1}
\]

**Temperature**

The DS18B20 sensor was used as the temperature sensor. The temperature sensor has been already calibrated in its fabrication [10]. The sensor has the operating range from -55°C to +125°C with an accuracy of ±2°C and it can achieve accuracy of ±0.5°C for the temperature range of -10°C to +85°C. The DS18B20 temperature sensor readings were compared with the thermometer in the laboratory.

#### 2.3. Blynk Application

The Blynk App helps to build a graphic interface in an Arduino program. Firstly, the Arduino was connected to a computer and run the Arduino IDE. Then the Blynk application was downloaded from Google Play store and installed into a mobile phone. The Blynk library was downloaded from www.blynk.cc [11] and then added into Arduino IDE. The Blynk app was used to display the data measured by the Kolora meter. Widget boxes were set and assigned to the respected virtual pins and sensors as shown in Table 2.
The temperature and turbidity sensors were integrated into the Blynk App to form Kolora Mobile app. This app consists of SuperChart, turbidity and temperature. The SuperChart was used to display the data measured by Kolora meter at different timestamp selection. This allows real-time data collection from the sensors.

| Sensor       | Virtual pins |
|--------------|--------------|
| Turbidity    | V2           |
| Temperature  | V3           |

2.4. Validation of Kolora meter
The validation of Kolora meter was done by performing water quality measurements in two conditions of water, clear and turbid water in the laboratory. However, the field testing has not yet been carried out and planned for future study.

3. Methodology
There were two water quality parameters, which is the turbidity and temperature, installed and measured in this study. The temperature and turbidity sensors were successfully installed and calibrated in Kolora meter. The calibration of the sensor was important to ensure the data collected is accurate and reliable. The Kolora application was developed to collect and save the data measured from Kolora meter remotely and wirelessly. After the calibration process, the Kolora device was tested for validation in the laboratory.

3.1. Parameter results

Turbidity
Prior the use of SEN0189 turbidity sensor, the calibration of the sensor was done by measuring the relationship different concentrations of suspended sediment (flour) in the water and its turbidity values as shown in Figure 3. The calibration of turbidity sensor method is based on the previous study, which used flour as sediment [9]. The coefficient of the turbidity sensor obtained from the value of R2, which at 0.9913. This shows a linear relationship of the total suspended solids in the solution and the cloudiness of solution. Therefore, this data is reliable to describe the relationship between turbidity reading and total suspended sediment.

![Figure 3. The relationship between turbidity and the total suspended solids.](image-url)
The graph of voltage against solution turbidity is illustrated in Figure 4. It shows that the voltage values decreased when the turbidity increased. Based on this graph, the sensitivity of the sensor was - 0.0012 with the maximum voltage operating at 4.0769 V. The coefficient of the voltage vs turbidity was obtained at 0.998. This coefficient is comparable with the value (0.9762) obtained by Hakim et al. (2019) [9]. This proves that the equation is suitable to be used for the turbidity sensor calibration in the Kolora meter.

![Figure 4. The graph of voltage value against turbidity.](image)

**Temperature**

The comparison of temperature data obtained from the laboratory thermometer and DS18B20 sensor is illustrated in Figure 5. The temperature of water sample was recorded based on the room temperature in the laboratory, which was ~25°C, for 10 minutes. The temperature readings were constant at 25°C until the 7th minutes of monitoring, however it slightly fluctuated to 5.12°C. This might be due to the instability or the movement of the sensor that might change the temperature readings. However, overall temperature readings from both sensor and laboratory thermometer showed similar value except at 7th minute. This shows that the Kolora temperature sensor is reliable and stable. It is reported that the thermometer sensor error is at ± 1°C for temperature range of -30°C to +100 [10]. It is also shown by Cruz et al. (2019) that the monitoring values of pH and temperature for almost 20 days in their study were noticeably close to the offline methods (using common laboratory apparatus) with less than 5% error [8].

![Figure 5. The comparison of the temperature readings obtained from the Kolora meter and laboratory thermometer.](image)
3.2. Kolora Mobile App
The Kolora Application was successfully linked to a smart phone. This is an advantage for an early detection of pollution and distance monitoring location due to its ability to monitor remotely. Furthermore, this device does not require people on duty at the monitoring sites. To prove the ability of Kolora meter, it was tested for clear and turbid water quality measurement at room temperature ~28°C. Figure 6 shows the real-time data of temperature and turbidity of tap water measurement and displayed by the Superchart in Kolora mobile app. It is shown that the continuous measurement of turbidity and temperature are represented by the graphs in the Superchart. The Kolora meter has an advantage for a long duration monitoring as it has options of 1h until 3 months continuous monitoring. The data collected can be monitored in real-time or recorded version. The graph can be displayed individually according to the parameter required by disabling the legend above the graph. The data can also be saved into CSV format for data compilation. However, further study needs to be done to measure the maximum distance coverage of the Kolora Mobile App via wi-fi and the Kolora Meter.

3.3. Validation Kolora meter
The Kolora meter was tested in two (2) conditions of water, clear and turbid water in room temperature as shown in Figure 7. Both conditions showed similar room temperature, which is 27.69 °C. The value turbidity of the turbid water measured using on-board sensor implemented in Kolora Meter was 428.75 NTU compared to 0 NTU in clear water. Further on field tests using this device will be carried out in future study.

![Figure 6. The interface of Superchart in Kolora Mobile App.](image-url)
4. Conclusion
A water quality monitoring device has been successfully developed using IoT system in this study. It has several advantages such as simple, low cost and it can be modified according to the needs of the researcher. Two sensors were successfully installed and calibrated in this early stage of study. The integration of online monitoring via Kolora meter App using mobile phone is an advantage for an early detection of pollution and distance monitoring location due to its ability to monitor remotely. Furthermore, this device does not require people on duty at the monitoring sites. The Kolora meter could also be used when there is limited movement especially during COVID-19 spread period. To prove the ability of Kolora meter, it was tested for clear and turbid water quality measurement at room temperature ~28°C in the laboratory and showed a promising and reliable results.

5. References

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