Proposed Study for Developing Low Cost River Water Quality Monitoring System using IoT Sensors and Artificial Intelligence Algorithms for Prediction of Water Quality

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Abstract:

Water is one of the primary requisites and crucial for sustaining the quality of life.

For this purpose, an Internet of Things (IoT) based water quality system capable of measuring the quality of water in real time is proposed.

The proposed solution is based on World Health Organization (WHO) defined water quality metrics, which include turbidity, temperature, dissolved oxygen level, pH level, dissolved ammonium, potassium, nitrate and conductivity. World Health Organization (WHO) has defined safe ranges for each of the water quality parameters as shown in Table 1.

<table>
<thead>
<tr>
<th>Sr#</th>
<th>Parameter</th>
<th>Safe Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>6.5 to 8.5</td>
</tr>
<tr>
<td>2</td>
<td>Turbidity</td>
<td>0 to 5 NTU</td>
</tr>
<tr>
<td>3</td>
<td>Hardness as CaCo3</td>
<td>500 mg/l</td>
</tr>
<tr>
<td>4</td>
<td>Conductance</td>
<td>2000 µS/cm</td>
</tr>
<tr>
<td>5</td>
<td>Alkalinity</td>
<td>500mg/l</td>
</tr>
<tr>
<td>6</td>
<td>Dissolved Solids</td>
<td>1000mg/l</td>
</tr>
<tr>
<td>7</td>
<td>Nitrate as NO2</td>
<td>&lt;1mg/l</td>
</tr>
<tr>
<td>8</td>
<td>Fecal Coliform</td>
<td>Nil Colonies/ 100ml</td>
</tr>
<tr>
<td>9</td>
<td>Calcium</td>
<td>200mg/l</td>
</tr>
</tbody>
</table>

• For this purpose, a real time embedded prototype will be developed to record the water quality parameters from the water samples collected from various sources across the study area. The sensors network sends data to cloud for real time storage and processing. The processed data can be remotely monitored.

• In addition to water quality monitoring and control system, the predictive analysis of the collected data will be performed. Therefore, advanced artificial intelligence (AI) algorithms will be developed to predict water quality index (WQI) and water quality classification (WQC).
Motivation:

In fact, the consequences of polluted drinking water are so dangerous and can badly affect health, the environment, and infrastructures.

As per the United Nations (UN) report, about **1.5 million** people die each year because of contaminated water-driven diseases.

In developing countries, it is announced that **80%** of health problems are caused by contaminated water.

**Five** million deaths and **2.5 billion** illnesses are reported annually.

Objectives:

To study all available Water Quality Monitoring System.

To design Low Cost River Water Quality Monitoring System using IoT Sensor Networks.

To predict water quality index (WQI) and water quality classification (WQC) using Artificial Intelligence Algorithms.

To visualize water quality parameters at realtime on a cloud server as well as mobile App.
Literature Review:
Many studies have been conducted to address water quality problems.
Following slides show some statistic about recently published papers (2018 - 2022).
Literature Review:

Number of Publications/country
Literature Review:

NUMBER OF PUBLICATIONS

- Indonesia: 16
- China: 5
- Taiwan: 3
- Malaysia: 3
- Philippines: 3
- Italy: 2
- Pakistan: 2
- Netherlands: 1
- USA: 1
- UAE: 1
- Sudan: 1
- Japan: 1
- Bangladesh: 1
- South Pacific: 1
- Fiji: 1
- Iraq: 1
- Canada: 1
- Australia: 1
- South Africa: 1
- Kenya: 1
- Nigeria: 1
- Brunei: 1
- Thailand: 1
Data processing, storage and visualization

- Cloud
- Computer based
- Web server
- Cloud, Android app
- SMS message, server unit
- Android app, web
- LCD Display
- Android app
- Sending Email, web
- SMS, FLASH memory storage
- Sending SMS
- Cloud, SMS
Literature Review: Types of Sensors
Types of Microcontroller

- Arduino Uno: 12
- Raspberry Pi: 9
- Arduino Mega 2560: 8
- STM32: 5
- ATMEGA 328: 2
- Arduino Bluno: 2
- LinkIt ONE development board: 1
- Atmega38p MCU based board: 1
- Adafruit Pro Trinket: 1
- ARM controller: 1
- Arduino ProMini: 1
- Pycm-fipy board: 1
- MSP432 Board: 1
- PIC18F26K20: 1
- MCU ESP8266: 1
- MCU Motherboard: 1
- Waspmote V1.2 microcontroller board: 1
- Node MCU ESP8266: 1
- ZigBee Tree structure: 1
- ALTERA FPGA Cyclone: 1
- ATMEGA328 microcontroller: 1
- Arduino nano 3.0: 1
Types of Communication Modules

- WiFi: 14
- GPRS/GSM: 13
- LoRa WAN: 8
- LoRa Gateway: 5
- Bluetooth: 4
- Zigbee XBee Module: 4
- N/A: 4
- A7139 RF: 1
- CAT Starter kit S767S: 1
Literature Review:

Data processing, storage and visualization

- Cloud: 18
- Computer based: 11
- Web server: 6
- Cloud, Android app: 4
- SMS message, server unit: 4
- Android app, web: 3
- LCD Display: 3
- Android app: 1
- Sending Email, web: 1
- SMS, FLASH memory storage: 1
- Sending SMS: 1
- Cloud, SMS: 1
Literature Review:

![Bar chart showing AVE_COST for different microcontroller boards and sensors. The chart compares the average cost of various boards and sensors, with the highest cost being for the Waspimote v1.2 board.](chart.png)
Literature Review:

Ave_Cost

- LoRa Gateway
- LoRa WAN
- GPRS/GSM
- Zigbee XBee Module
- CAT Starter kit S7675
- WiFi
- Bluetooth
- Zigbee XBee Module
Methodology:

Wireless Sensors Network using GSM Network
Methodology:

Wireless Sensors Network using LoRa Network

LoRa Network

Cloud Server

Data visualization
Methodology:

Water quality index (WQI) prediction

For the WQI prediction, artificial neural network models, namely nonlinear autoregressive neural network (NARNET) and long short-term memory (LSTM) algorithm, will be used.

For the water quality classification (WQC) forecasting.

Three machine learning algorithms, support vector machine (SVM), K-nearest neighbor (K-NN), and Naive Bayes, will be used for the WQC forecasting.
Aim of this study is:

Reviewing all available Water Quality Monitoring System have been carried out in a few past years (2018-2022).


Visualizing water quality parameters at real-time on a cloud server as well as mobile App.
References


