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Industrial Waste Water Contamination Level Monitoring System Using Lora

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ABSTRACT

Water contamination is a significant environmental concern that requires effective monitoring systems to ensure the safety and quality of water resources. This paper proposes a Water Contamination Level Monitoring System using LoRa (Long-Range) transceiver technology, along with multiple sensors, including temperature, NPK (Nitrogen, Phosphorus, Potassium), pH, and turbidity sensors.

The proposed system utilizes sensor nodes equipped with these sensors deployed in water bodies to measure various parameters in real-time. The sensor nodes communicate wirelessly with a gateway node using LoRa technology, enabling long-range, low-power communication even in remote and challenging environments.

Keywords*:* LoRa , Wireless data Transfer.

1. INTRODUCTION

Water contamination is a significant environmental concern that poses risks to public health, agriculture, and aquatic ecosystems. Monitoring the quality of water resources is crucial to detect and mitigate water contamination events promptly. In recent years, advancements in sensor technologies and wireless communication have enabled the development of effective water contamination level monitoring systems.

In this report, we present a comprehensive approach for monitoring water contamination levels using a Water Contamination Level Monitoring System based on LoRa (Long-Range) transceiver technology. The system utilizes multiple sensors, including temperature, NPK (Nitrogen, Phosphorus, Potassium), pH, and turbidity sensors, to measure key parameters related to water quality.

The temperature sensor measures the water temperature, which is an important parameter for understanding water quality variations and potential impacts on aquatic life. The NPK sensor measures the levels of nitrogen, phosphorus, and potassium, which are essential nutrients for plant growth but can also indicate pollution from agricultural runoff. The pH sensor measures the acidity or alkalinity of the water, providing insights into changes in water quality that may affect aquatic ecosystems and human health. The turbidity sensor measures the clarity or cloudiness of water, which can indicate sedimentation or pollution levels that impact water quality.

The proposed Water Contamination Level Monitoring System leverages LoRa technology for long-range, low-power communication between sensor nodes and a gateway node, enabling remote and efficient data collection in challenging environments. The collected sensor data is transmitted to a central server, where it is processed, analyzed, and visualized through a web-based user interface. The system also includes data validation, integrity, and security mechanisms to ensure reliable and accurate monitoring results.

This report provides an overview of the Water Contamination Level Monitoring System, including the system architecture, sensor technologies, data collection and transmission, data processing and analysis, and user interface. The report discusses the potential benefits of the system, such as early detection of water contamination events, prompt response to mitigate risks, and informed decision-making for water resource management and protection. It also highlights the importance of using advanced technologies, such as LoRa transceiver and various sensors, for effective water quality monitoring in today's environmental context.

2. THEORY OF OPERATION

In the current scenario, there comes a lot of challenges to monitor the quality of water owing to human disaster, population growth and, sudden changes in the environment. This mechanism is being designed and developed with a low-cost- effective monitoring system for the principal parameters in real-time. In proposed work. Turbidity, Temperature, pH and NPK. Are used to measure the quality of water continuously. In addition to physical parameter sensors Quality Analyzer is used. In this work, the sensors are connected to the arduino Uno microcontroller that it transmits the sensed data to the cloud which act as LoRa Receiver. Furthermore, the stored data in the pega Server and used for further analysis pc monitoring mechanisms.. With the help of these components, if any of the values crosses its parameter level then it is an imbalance in water and it is not suitable to mix in the surrounding water bodies.The whole system is powered by using the low power step down transformer. Wireless data transfer system system, such as data encryption, compression and reducing the amount of data traffic that need to be transmitted back to the base station. Methodology The introduced system is in a position to extract the data from the water samples by sensors through the Node MCU and analyze them. Power consumption profiles of various sub-systems are characterized to make sure sustainable operation of the sensor system. This method comprises of mainly two sections: the first part consists of setting up an Arduino board, and interfacing it with sensors.

The second part consists of developing a LoRa platform and linking it to the server for notification purposes. Arduino Board which is connected to the different sensors are Temperature sensor, like temperature, NPK (nitrogen, phosphorus, and potassium), pH and turbidity level of the water. With the help of GPIO pins. The arduino Uno collects all the data from sensors and sends it to the PC platform. The data can be access through Desktop subordinately across the world where desktop acts as a LoRa Receiver.

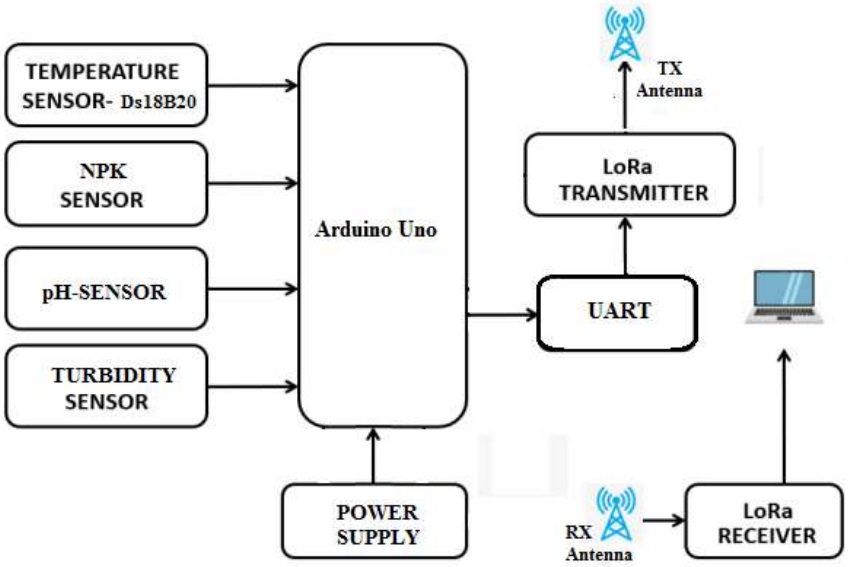

Fig 1. Block Diagram

A. Hardware Components

1) Arduino Uno (ATmega 328)

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Fig 2. ATmega 328

Analog Input Pins: The Arduino Uno has 6 analog input pins, labeled as A0 to A5. These pins can be used for reading analog signals from sensors such as temperature sensors, light sensors, and potentiometers. The analog input pins have a resolution of 10 bits, allowing for a range of values from 0 to 1023.

PWM Pins: The Arduino Uno has 6 Pulse Width Modulation (PWM) pins, labeled as D3, D5, D6, D9, D10, and D11. These pins can be used for generating analog-like signals with varying duty cycles, making them suitable for controlling devices such as motors, LEDs, and servos.

Serial Communication: The Arduino Uno supports serial communication through its hardware UART (Universal Asynchronous Receiver/Transmitter) interface. It has one hardware UART, which can be used for communication with other devices such as computers, other microcontrollers, and sensors.

Operating Voltage: The Arduino Uno can be powered using a DC power supply ranging from 7 to 20 volts or through its USB port. The onboard voltage regulator provides a stable 5V output, which can be used to power external components connected to the board.

Memory: The ATmega328P microcontroller on the Arduino Uno has 32KB of Flash memory for storing the program code, 2KB of SRAM for data storage, and 1KB of EEPROM for storing data that needs to be retained even when power is off.

Programming: The Arduino Uno can be programmed using the Arduino Integrated Development Environment (IDE), which provides a user-friendly interface for writing, compiling, and uploading code to the microcontroller. The programming language used is a simplified version of C++, with a set of Arduino-specific libraries for controlling the board's various features.

Dimensions: The Arduino Uno has dimensions of approximately 68.6mm x 53.4mm, making it a compact and easy-to-use board for prototyping and building electronic projects.

Overall, the Arduino Uno (ATmega328) is a versatile and widely used microcontroller board that provides an excellent platform for learning, prototyping, and building various electronic projects. Its simplicity, wide range of compatible sensors and modules, and extensive online community make it a popular choice among hobbyists, students, and professional developers alike.

2) **1 Three-Way Soil Meter For Moisture, Light Intensity**

Fig 3 *Three-Way pH meter*

The Three-Way Soil Meter pH meter is a device used for measuring the acidity or alkalinity of soil in gardening, farming, and agricultural applications. It typically consists of a handheld device with a digital or analog display and three probes that are inserted into the soil to obtain readings.

pH Probe: The pH probe is designed to measure the pH level of the soil, which indicates whether the soil is acidic, neutral, or alkaline. The probe is usually made of durable materials, such as stainless steel or glass, and has a sensitive electrode that reacts with the soil to provide accurate pH readings.

Moisture Probe: The moisture probe measures the moisture content of the soil, which helps determine whether the soil is too dry, too wet, or at an optimal moisture level for plant growth. It usually consists of two or more prongs that are inserted into the soil to measure the electrical resistance, which is then correlated to the soil moisture level.

Light Probe: The light probe measures the intensity of light in the surrounding environment, which is essential for assessing whether the plants are receiving adequate light for photosynthesis. It typically has a light sensor that captures the intensity of light in lux or foot-candles and provides readings on the display.

The Three-Way Soil Meter pH meter is easy to use, and the readings are typically displayed on a digital or analog screen, allowing the user to quickly assess the pH level, moisture content, and light intensity of the soil. This information helps gardeners and farmers make informed decisions about adjusting soil conditions to optimize plant growth and productivity. The device is often battery-powered and portable, making it convenient for use in the field or garden. Some advanced models may also come with additional features such as temperature measurement, data logging, and wireless connectivity for remote monitoring and analysis.

3) NPK Sensor

Fig 4. NPK Sensor

NPK sensors, also known as nutrient sensors or fertilizer sensors, are devices used to measure the levels of essential plant nutrients, namely nitrogen (N), phosphorus (P), and potassium (K), in soil or plant tissue. These sensors are commonly used in agriculture, horticulture, and precision farming to optimize fertilization strategies and improve crop yield and quality.

Description of NPK Sensor:

A typical NPK sensor consists of a probe or sensor element, which is inserted into the soil or in contact with plant tissue, and a connected electronic device or system that interprets and displays the nutrient readings. The probe typically contains one or more sensors that are capable of measuring the concentration of each nutrient in the soil or plant tissue.

Working of NPK Sensor:

The working principle of NPK sensors can vary depending on the specific type and technology used, but generally, NPK sensors work based on one or more of the following principles:

Electrical Conductivity (EC): NPK sensors can measure the electrical conductivity of the soil or plant tissue, which is related to the concentration of dissolved ions, including N, P, and K. The higher the concentration of these nutrients, the higher the electrical conductivity.

Optical Absorption or Reflectance: Some NPK sensors use optical principles to measure nutrient levels. They emit light at specific wavelengths and measure the amount of light absorbed or reflected by the soil or plant tissue. Nutrient concentrations can be correlated with the amount of light absorbed or reflected, providing nutrient readings.

Ion-Selective Electrode (ISE): NPK sensors can also use ion-selective electrodes (ISE) that are selective to specific ions, such as N, P, or K. These electrodes measure the potential difference or voltage generated when the nutrient ions bind to the electrode surface, which is proportional to their concentration.

4) TURBIDITY SENSOR

- High reliability
- Fast response
- Waterproof design
- Long lifespan

The AZDM01 turbidity sensor is a device used to measure the turbidity or cloudiness of a liquid, typically water. It is commonly used in various applications such as water quality monitoring, environmental monitoring, and industrial processes where measuring the clarity of a liquid is important.

Description of AZDM01 Turbidity Sensor:

The AZDM01 turbidity sensor typically consists of a probe or sensor element, which is submerged in the liquid being measured, and a connected electronic device or system that interprets and displays the turbidity readings. The probe typically contains one or more optical sensors that are capable of measuring the scattering or absorption of light caused by suspended particles in the liquid.

Working of AZDM01 Turbidity Sensor:

The working principle of the AZDM01 turbidity sensor is based on the scattering of light by suspended particles in the liquid. When light passes through a liquid with suspended particles, such as sediment, algae, or other contaminants, the particles scatter the light in different directions, causing the liquid to appear cloudy or turbid. The AZDM01 sensor measures the intensity of the scattered light and provides a turbidity reading as a measure of the concentration of suspended particles in the liquid.

The AZDM01 turbidity sensor typically uses an LED (light-emitting diode) as the light source and a photodetector to measure the intensity of the scattered light. The sensor may use either a nephelometric or a turbidimetric method for measuring turbidity:

Nephelometric Method: In the nephelometric method, the sensor measures the intensity of the scattered light at an angle to the incident light. The angle and distance between the light source and the photodetector are carefully calibrated to ensure accurate turbidity measurements. The sensor may also use multiple detectors at different angles to measure the scattered light, allowing for more precise and reliable turbidity readings.

Turbidimetric Method: In the turbidimetric method, the sensor measures the decrease in intensity of the transmitted light due to scattering by suspended particles. The sensor typically measures the intensity of the transmitted light before and after passing through the liquid, and calculates the turbidity based on the difference in intensity.

Calibration and Data Interpretation:

The AZDM01 turbidity sensor typically requires calibration to establish a relationship between the sensor readings and actual turbidity values. Calibration is done by measuring known turbidity values using a reference standard, and correlating them with the sensor readings. Once calibrated, the sensor readings can be interpreted to provide turbidity values in units such as NTU (Nephelometric Turbidity Units) or FTU (Formazin Turbidity Units), which are commonly used units for turbidity measurement.

Data Analysis and Management:

The AZDM01 turbidity sensor may be connected to a data logger or a digital device that collects and stores the sensor readings over time. This data can be analyzed to track changes in turbidity levels, monitor water quality, and trigger alarms or actions based on preset turbidity thresholds.

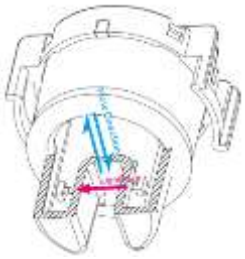

Fig 5 Turbidity sensor

5) DS18B20 Temperature Sensor

Fig 6 .Temperature Sensor Module

The DS18B20 is a 1-wire programmable Temperature sensor from maxim integrated. It is widely used to measure temperature in hard environments like in chemical solutions, mines or soil etc. The constriction of the sensor is rugged and also can be purchased with a waterproof option making the mounting process easy. It can measure a wide range of temperature from -55°C to +125° with a decent accuracy of ±5°C. Each sensor has a unique address and requires only one pin of the MCU to transfer data so it a very good choice for measuring temperature at multiple points without compromising much of your digital pins on the microcontroller. The sensor works with the method of 1-Wire communication. It requires only the data pin connected to the microcontroller with a pull up resistor and the other two pins are used for power The pullup resistor is used to keep the line in high state when the bus is not in use. The temperature value measured by the sensor will be stored in a 2-byte register inside the sensor. This data can be read by the using the 1-wire method by sending in a sequence of data. There are two types of commands that are to be sent to read the values, one is a ROM command and the other is function command. The address value of each ROM memory along with the sequence is given in the datasheet below. You have to read through it to understand how to communicate with the sensor.

6. LORO

Long-range radio communication, or LoRa, is a type of physical radio communication. It is based on chirp spread spectrum (CSS) and spread spectrum modulation (SSM) technologies. Lora WAN specifies both the system architecture and the communication protocol. ITU-T Y.4480, often known as Lora WAN, is a standard for the organization (ITU). LoRaWAN is a wireless WAN (Wide Area Network) protocol that enables long-range, low-power communication between IoT devices. It is designed to operate in the sub-gigahertz frequency bands and allows for long-range communication with low power consumption. The LoRa Alliance is an open, non-profit association of members who are committed to developing and promoting the LoRaWAN protocol as a global standard for IoT networks. Semtech is one of the founding members of the LoRa Alliance and is a key supplier of LoRa technology. A channel's Lora WAN data rate might be anything from 0.3 and 50 kbit/s. We are employing the NRL24L01 instead of LoRa for our suggested system since model experiments might differ from real-time experiments. Zigbee NRL24L01 is therefore used for this suggested one. The NRL24L01 data modem has automated receive/transmit mode switching, LED indication, and half-duplex operation at 2.4 GHz. It seems like you are describing a wireless communication module that can be used to send and receive data through a serial port or similar device. The module operates at a variable baud rate of 9600/4800/38400/19200 bps and uses the RS232 level for serial communication. It can be used with other 2.4 Ghz Sensor embedded models (TTL, 30 metre range) or with the NRL24L01 modem for two-way wireless data transmission with a higher data rate and greater transmission distance. The communication protocol is self-contained and transparent to the user interface, making it easy to integrate into existing designs.

B. Software Components

3. SOFTWARE COMPONENTS

1. ARDUINO IDE
2. PEGA APPLICATION
3. VISUAL BASICS

1. ARDUINO IDE

The Arduino IDE is a software tool that provides an easy-to-use interface for programming Arduino microcontroller boards. It includes features such as a code editor, compiler, library manager, board manager, serial monitor, examples, upload manager, cross-platform support, and open-source nature. It allows users to write, compile, and upload code to Arduino boards, making it popular for prototyping and developing electronic projects.

The Arduino IDE is designed to be user-friendly, making it accessible to those with little or no programming experience. It provides a code editor with syntax highlighting and autocompletion, a library manager for easy integration of pre-written code, and a board manager for managing different Arduino boards. The IDE also includes a serial monitor for debugging, examples for learning, and an upload manager for seamless deployment of code to Arduino boards. Being open-source and available for multiple operating systems, the Arduino IDE has a strong community of users and developers, constantly improving and extending its capabilities.

2. PEGA APPLICATION

Pega is a low code platform for AI-powered decisioning and workflow automation. Pega provides a powerful low-code platform that empowers the building of workflows as a simple user understandable. Pega helps you make better decisions and get work done.

Pega is a popular Business Process Management (BPM) tool created by JAVA concepts that allow users to execute changes faster than Java-Based applications. The primary use of Pega is to reduce costs and improve business reasons. Pega is created in Java and uses OOP and Java ideas.

3. VISUAL BASICS INTERFACE

Visual Basic (VB) is an event-driven programming language and integrated development environment (IDE) developed by Microsoft. It is designed to provide a graphical user interface (GUI) programming environment that simplifies the creation of Windows desktop applications.

The Visual Basic programming language is a high-level language that is easy to learn and use. It uses a graphical user interface (GUI) to enable developers to create user interfaces that are intuitive and easy to use. It also includes many pre-built controls and components, such as buttons, text boxes, and menus, which can be easily dragged and dropped onto a form.

4. RESULT AND ANALYSIS

The project has been set up with the components on an efficient manner and our system can monitor water quality automatically, and it is cost-effective with low power consumption and minimal human intervention. So water quality testing is probably going to be more economical, convenient and fast. The system has good flexibility. Environmental conditions such as Temperature, pH , turbidity and NPK values are studied to check the outlet water quality and its feasibility for mixing with the water bodies. The changes in the concentration of impurities in the water and soil due to natural and human causes can be easily analyzed. The observed water quality data of water samples is shown in Fig.9, Fig10, Fig 11, Fig 12.Then the gathered data and observed results will be available to the end user through the Wi-Fi and IoT Application. Hence, We can get Enhanced accuracy with real time data collection.

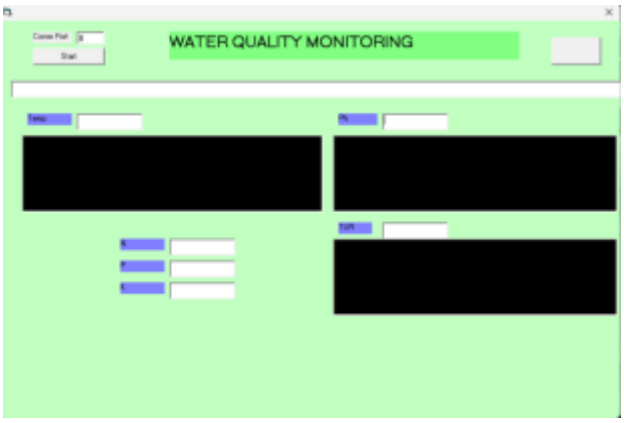

Fig 7 Visual Basic interface

The above image is the visual basic interface for our water quality monitoring system. In this interface, we can see the real-time values which are measured by the sensors and are then transferred by using a Loro transmitter which is received by the Loro receiver connected to our laptop where we can see the live values and graphical representation.

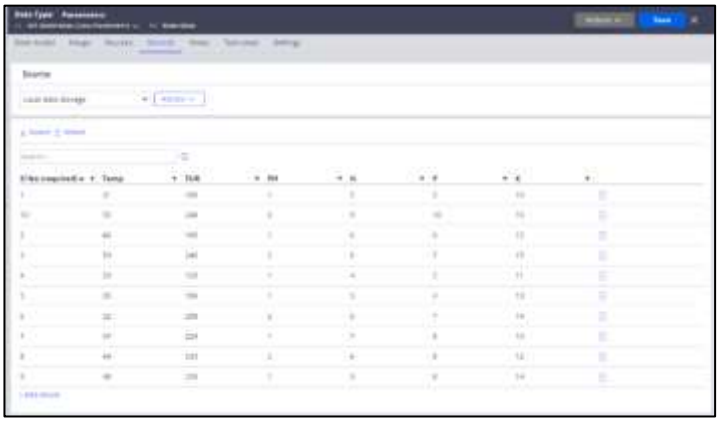

Fig 8 PEGA DATABASE

The above figure 8 is the image of the base database with the list all sensor values.

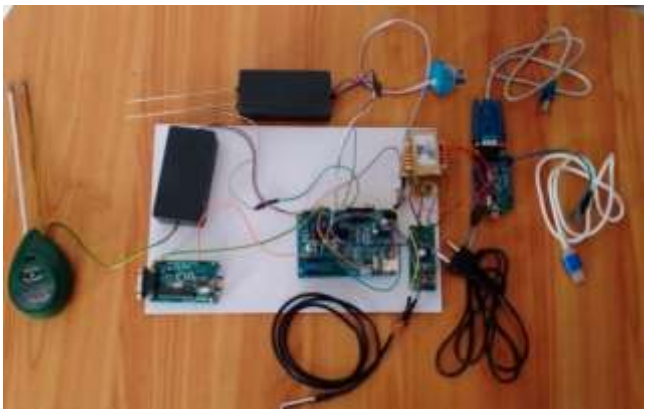

Fig 9 Project Hardware set up

The sensor live values can be seen in the Visual basics interface along with the graphical representation and these values are stored in and excel file. These values are then uploaded to pega server where the analysis begins. Here, the sensors values are compared with the predefined standard values and then if measured values are over the standard values then a email alert is triggered to the respected reporting mail id along with the industry details and the non-desirable values in list.

Fig 10 . Final Output Alert Mail

5. CONCLUSION

The system can monitor water quality automatically, and it is cost-effective with low power consumption and minimal human intervention. So the water quality testing is probably going to be more economical, convenient and fast. The system has good flexibility. Environmental conditions such as Temperature, Humidity, Conductivity and Air Quality are studied to check its feasibility for agriculture. The changes in the concentration of impurities in the water and air due to natural and human causes can be easily analyzed. The observed water quality data of water samples and components is shown in Fig.7, Fig8, Fig 9, Fig 10.Then the gathered data are stored in the pega database and observed results will be available after analysis of the sensor values if the values are higher than the standard then alert mail is triggered to thespecifically targeted user mail. Hence, We can get Enhanced accuracy with real-time data collection.

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