

Development of a Real-Time PH-Based Water Pollution Detection System Using Arduino

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ABSTRACT: In today's world, Arduino microcontrollers play an important role in connecting technology to everyday life. This project presents a low-cost and efficient water pollution detection system using the Arduino Nano, pH sensor, and LCD display. The main goal is to help users determine whether water is safe to use by measuring its pH level, indicating if it is acidic, alkaline, or neutral. This system is designed to monitor water quality in real time. When the pH sensor is placed in water, it measures the pH level and sends the data to the Arduino Nano. The results are then displayed on an LCD screen. If the water is found to be contaminated or outside the safe pH range, the system alerts users by displaying the pH value and activating a buzzer to warn the surrounding community. This system setup allows for continuous monitoring and real-time updates, ensuring users are always informed about the current water quality. Unlike traditional methods, this system offers a more accurate, accessible, and immediate way to check water conditions. It is especially useful in areas where access to clean water is limited or water pollution is a concern. Developed with minimal cost and using open-source technology, the system is practical for public use and community awareness. The ultimate aim is to assist individuals, especially in Malaysia, in identifying unsafe water sources and reducing the risk of consuming polluted water, thereby improving public health and safety.

Keywords: *Arduino Nano, pH Sensor, Water Quality, Water Pollution Detection, LCD displays*

1.0 INTRODUCTION

Water is the second most essential element for life, following only air. It plays a crucial role in the survival of all living organisms, especially in facilitating bodily metabolic processes. Refer to Chaplin (2001), water is the second most essential element for life, following only air. It plays a crucial role in the survival of all living organisms, especially in facilitating bodily metabolic processes.

The pH sensor is a critical instrument for assessing water quality, as it measures the acidity or alkalinity of aqueous solutions. Accurate application of pH sensors is essential in maintaining product integrity and process efficiency, particularly within wastewater treatment and industrial manufacturing contexts. The pH scale ranges from 0 to 14, with a value of 7 representing a neutral state. Readings above 7 denote alkaline conditions, while values below 7 indicate acidity. For example, toothpaste typically exhibits a pH level between 8 and 9, whereas gastric acid possesses a pH close to 2. Comprehending the distinction between acidic and alkaline substances is vital across various domains, including industrial production, swimming pool maintenance, and environmental monitoring. The human body maintains an average pH of approximately 7.4, which is essential for optimal physiological function. Deviations from this balance toward either extreme prompt the body's natural mechanisms to reestablish equilibrium. Consequently, preserving the safety and purity of water is imperative to ensure its suitability for daily consumption and usage.

According to Cheniti (2017), even highly developed Western nations remain vulnerable to the risks posed by water pollution. In the summer of 2019, a serious outbreak of *Campylobacter* and *Escherichia coli* (*E. coli*) occurred in the drinking water supply of Asky located on Norway's west coast. The incident affected over 2,000 people, with more than 60 individuals hospitalized and two reported deaths.

The deterioration of both surface and groundwater quality presents a major threat to public health, particularly in areas where water is used for drinking, agriculture, and sanitation. Contaminants such as heavy metals, nitrates, and pathogens can result in serious health consequences, including gastrointestinal illnesses, reproductive problems, and neurological disorders (World Health Organization, 2017). Therefore, regular monitoring and proper water treatment are essential to ensure community safety. Patel (2017) mentioned that assessing water quality typically involves evaluating physicochemical properties, biological factors, and concentrations of heavy metals.

In the research by Kihara et al. (2013) said water quality across all regions complied with international standards, likely influenced by regional geochemical conditions, geological and geographical characteristics, and the natural purification capacity of the environment. However, fecal contamination was widespread in developing countries and present at several sites in Japan. This finding highlights the urgent need for sewage treatment systems, proper drainage infrastructure, and effective monitoring protocols, particularly in developing nations. Rivers in these areas are heavily impacted by high population density, industrial discharge, and agricultural activities, which contribute to both organic and inorganic pollution.

pH sensors enable precise control of pH levels, which can vary from strong acids to highly alkaline substances. There are several types of pH sensors available for liquid measurement, including combination pH sensors, laboratory sensors, process sensors, and differential sensors. Refer to Islam (2015) the pH Electrode Probe E-201-C PHS-25 is selected as the primary sensor due to its high accuracy in measuring pH values.

1.3. Project scope

This study focuses on the engineering properties of the pH sensor (focus). The type of material used in pH sensor is measurement of ORP (Oxidation-Reduction Potential) and pH value. There were two type of water sample that had been taken which are acidic and alkaline from the lake at Politeknik Tuanku Syed Sirajuddin. The size of the sensor is 155 x 27.5 x 12mm and had been tested in transverse wave. The reading that has been taken from pH sensor will be display at lcd display. When the pH sensor detects the water pollution, the buzzer will sound to provide an early warning to the public.

1.4. Project impact

The research finding will contribute towards the application of pH sensor as a replacement for water quality monitoring sensor hence improve the quality of pH sensor. This research involving a study on the capability of water sensors to accurately take readings when placed into water sample.

In other hand, it also provides early warning to the public if the area is contaminated and not suitable for recreational activities, signaled by the sound of a buzzer. The cost of producing this project is cheaper than purchasing ready-made product in the market.

3.0 METHODOLOGY

Generally, the development of this project involves two main components: hardware development and software development. The hardware development process involves activities such as creating control circuits, intermediate circuits, power supply circuits, and designing a prototype model of an automatic water level controller. The software development process, on the other hand, involves activities such as designing the overall process flowchart, writing software in the Arduino IDE, and developing a web socket.

Refer to Figure 1, which illustrates the operational process of the water pH monitoring system. The sequence initiates with the activation of the main switch, thereby powering the system. Subsequently, the pH sensor measures the pH level of the water. The detected value is then transmitted and displayed on an LCD screen for real-time monitoring. The system checks whether the pH value is exactly 7, which indicates that the water is neutral and generally safe. If the pH is 7, the system loops back to continue monitoring. However, if the pH value is outside the neutral range either less than 7 (acidic) or greater than 7 (alkaline) the system triggers a buzzer to alert the user that the water may not be safe. The process then ends, awaiting further action.

This system provides a simple yet effective way to continuously monitor water quality based on its pH level.

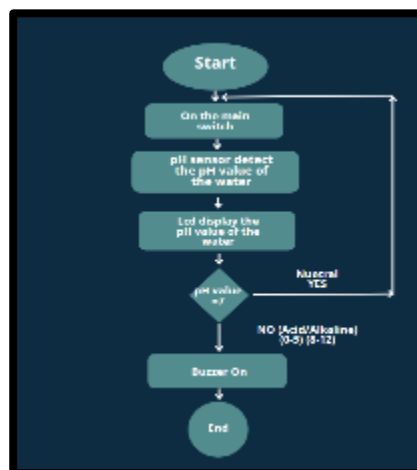


Figure 1: Flow Chart of pH pollution detector project

Adi et al. (2024), the effectiveness of an IoT-based system utilizing pH sensors to replace traditional manual monitoring by delivering precise readings when immersed in water and activating a buzzer alarm when critical levels are exceeded.

4.0 DATA ANALYSIS AND FINDINGS

4.1. Calibration of pH Sensor

Model calibration consists of adjusting the model of the pH sensor as an input parameter, the initial condition of water pH level so that model simulates the alert system. The calibration process involves matching water pH level, buzzer and LCD display changes as well as a range of pH scale. Refer to table 1, the principal work of pH sensor within this experiment acquired with three conditions:

Table 1 : Calibration of pH sensor based on the type of liquid or water sample

No.	Test description	pH scale	system response
1	Plain water is add on with high acidic and with different concentration	2-5	Buzzer is activated
2	Plain water is added with high alkaline with different concentration	10-12	Buzzer is activated
3	pH sensor of the plain water and display the reading on lcd display	6 -7	Buzzer is deactivated

Refer to table 2, when the system is turned on, the sensor detects the type of water based on its pH level and sends the information to be displayed on the LCD screen. If the water is neutral, the sensor detects a pH value between 6 and 7, and no buzzer is activated. In the case of acidic water, the sensor detects a pH level between 2 and 5, the LCD displays this range, and the system triggers a beeping sound from the buzzer to alert the user. Similarly, if the water is alkaline, with a pH range of 9 to 12, the buzzer will also beep, warning that the water is not neutral. This setup ensures that any deviation from the safe pH range is immediately signaled through sound, helping users take necessary action.

Table 2: Result of pH water detection based on water type

Water type	Sensor	LCD display In pH scale	Buzzer
Neutral	Detecting	6-7	None
Acidic	Detecting	2-5	Beep
Alkaline	Detecting	9-12	Beep

The hardware setup and functionality of a pH monitoring system using an Arduino Uno. At the core of this system is the pH sensor, specifically the E201C-Blue model, which plays a crucial role in detecting the pH level of water. This sensor is capable of identifying whether the water is neutral (pH 6–7), acidic (pH 2–5), or alkaline (pH 9–12).

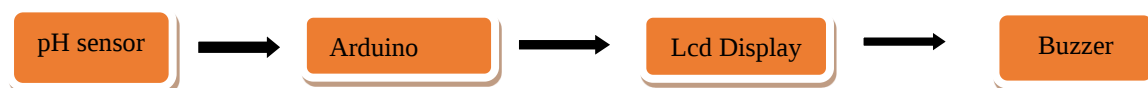


Figure 2: Step pH sensor after get the data

Figure 2 above describe the hardware setup and functionality of a pH monitoring system using an Arduino Uno. At the core of this system is the pH sensor, specifically the E201C-Blue model, which plays a crucial role in detecting the pH level of water. This sensor is capable of identifying whether the water is neutral (pH 6–7), acidic (pH 2–5), or alkaline (pH 9–12).

The pH sensor has three pins:

- Vcc (positive supply voltage)– the power supply pin, which requires a 5V input from the Arduino Uno to activate the sensor.
- Signal – the pin responsible for transmitting data (i.e., the detected pH level) to the Arduino.
- GND(Ground) – the ground pin, which completes the electrical circuit by connecting to the Arduino’s ground.

In this system, once the pH sensor detects the water's pH level, it sends this signal to the Arduino Uno, which processes the data. The processed information is then displayed on an LCD screen so users can read the pH value in real time. If the pH value falls outside the safe (neutral) range, the Arduino triggers a buzzer as an alert.

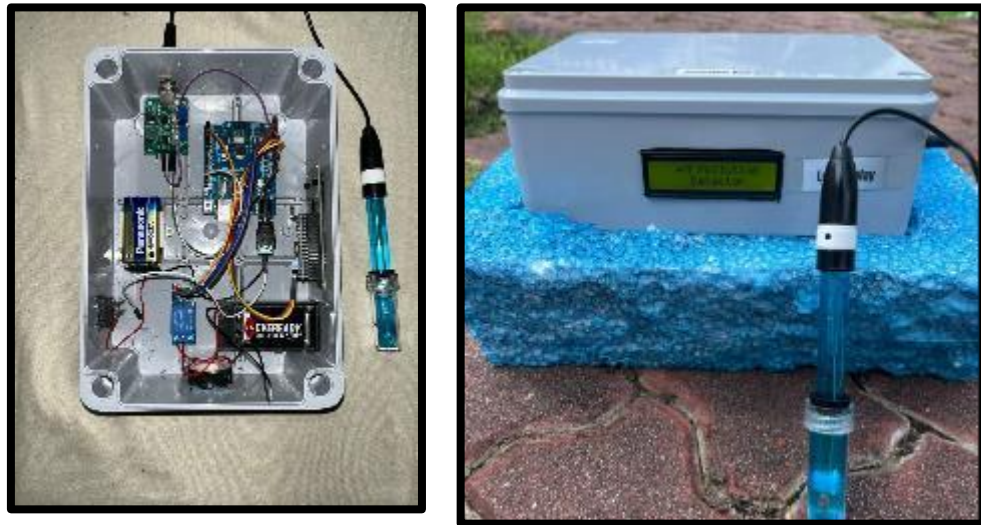


Figure 3: pH Pollution detector

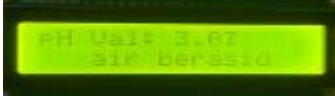
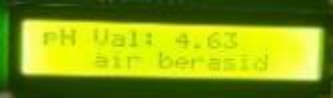
Figure 3 above shown the prototype of pH Pollution detector, where the systems is linear process from sensing to display and alert makes the system highly efficient for real-time of pH water quality monitoring. The inclusion of simple hardware like the Arduino Uno and LCD display ensures the project remains user-friendly and practical for educational or small-scale environmental monitoring purposes.

Table 3: Analysis of alkaline liquid testing according to viscosity levels

No	Water Type	Concentration	Category	Status buzzer	LCD Display
1	Alkaline	300ml	Dangerous	Beep	
2	Alkaline	250ml	Dangerous	Beep	
3	Alkaline	200ml	Dangerous	Beep	

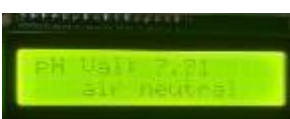
To conclude the data results from Table 3 above, the alkaline levels at different concentrations, it appears that as the concentration increases, the alkalinity also increases. This suggests a direct relationship between alkaline concentration and alkalinity levels. Further analysis may be needed to understand any potential thresholds or saturation points. If more plain water add on into the alkaline container, the result on lcd display may be decrease to pH 8 due to low concentration.

Table 4: Analysis of acidic liquid testing according to viscosity levels

No.	Water Type	Concentratio n	Category	Status buzzer	LCD Display
1	Acidic	200ml	Dangerous	Beep	
2	Acidic	250ml	Dangerous	Beep	
3	Acidic	300ml	Dangerous	Beep	

Based on the data results in Table 4 , it seems that as the concentration of acidity increases, the pH level decreases. Additionally, pouring more water onto the testing kit appears to dilute the acidity, resulting in a higher pH reading. This indicates a negative correlation between acidity concentration and pH level, and it suggests that dilution can alter the acidity reading.

Table 5: Analysis of alkaline liquid testing according to viscosity levels

No.	Water Type	Concentration	Category	Status buzzer	LCD Display
1	Neutral	200ml	Safe	No	
2	Neutral	250ml	Safe	No	
3	Neutral	300ml	Safe	No	

The data results in Table 5, indicate that the pH level of neutral water remains consistent regardless of its concentration. This consistency is expected because neutral water, by definition, has a pH level of around 7, indicating a balance of hydrogen ions and hydroxide ions. Therefore, variations in concentration do not significantly affect its neutrality.

5.0 DISCUSSION AND CONCLUSIONS

This work proposed the development of the technology for water control using pH scaling in Malaysia mainly for water pollution disaster to minimize the loss of aquatic life and risky human life by consuming polluted water. This project can help authorities to monitor the pH water throughout Malaysia through the use of water pollution detector compared to the existing systems. The prototype of the proposed design was successfully built and tested in house. It was able to record the water pH level and show it on LCD display and sound the buzzer if the water was polluted.

The water pollution detector of the proposed system employed the pH sensor have been successfully become a direct reading instrument of water pH level and the LCD display show the water pH level in pH scale. The buzzer will make sound when the pH sensor detects that the water is not suitable to be used for daily life of human and for the aquatic life.

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