INTERNATIONAL JOURNAL OF ADVANCED INNOVATIVE TECHNOLOGY IN ENGINEERING

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Smart Urine Health Monitoring System

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Article History

Received on: 20 July 2026

Revised on: 15 Aug 2026

Accepted on: 20 Sept 2026

Keywords: pH Sensor, TDS Sensor, DS18B20 Temperature Sensor, Node MCU ESP8266

e-ISSN: 2455-6491

DOI: 10.65809/IJAITE/26/v03sp02/010

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ABSTRACT

A hardware-focused medical device, the Smart Urine Health Monitoring System offers real-time monitoring and assessment of the parameters present in the urine sample obtained via the urine container. The hardware configuration measures the health parameter values in the urine sample using a number of sensors, including the pH sensor, the DS18B20 temperature sensor, and the Total Dissolved Solids (TDS) sensor. The NodeMCU ESP8266 microcontroller effectively processes the measured parameters in the urine sample. The system is powered by a 5V USB power source, which makes it easier to use and more portable. The LCD screen shows the measured health parameters, giving users access to real-time data. It can identify a number of illnesses, including kidney function issues, urinary tract infections, and dehydration. The suggested system can be used to monitor people's general health at home and is affordable and simple to use. The current work enables the early detection of health issues and does away with the need for laboratory testing. Future advancements might include integrating the system with the Internet of Things (IoT), allowing it to be connected to a mobile application, and enabling remote health monitoring.

1. INTRODUCTION

Urine analysis is considered to be one of the most basic yet widely used techniques used by health practitioners today. This method is used as it helps identify various metabolic and physiologic functions within the body. For instance, the analysis can help detect various issues such as kidney disorders, urinary infections, diabetes, and dehydration. Therefore, the continuous evaluation of the urine production parameters is considered one of the most important aspects of ICU operation since it gives valuable information on the status of the organs within the patient's body.

At the same time, conventional health monitoring techniques are characterized by

numerous flaws which hinder their applicability. First and foremost, most of these techniques require regular human intervention and supervision as well as manual calculations. Such flaws may result in significant delays in the process of the urine analysis which in turn may negatively impact health practitioners' decisions about their patients. Second, there is a chance that the results collected will include some human errors thus affecting further analysis. Finally, such methods as manual monitoring do not provide continuous information on the patient's status.

Therefore, the development and utilization of various technologies in health monitoring should be considered extremely important. One of the most promising developments which should be mentioned is the introduction of the Internet of Things. Using these technologies allows gathering, analyzing, and transmitting data regarding patient's status in a fast and efficient manner. Therefore, the use of the Internet of Things (IoT) technology can have a profound positive effect on the field of healthcare. The purpose of the proposed project -- Smart Urine Health Monitoring System -- is to develop an innovative system for measuring and analyzing urine parameters. This task will be achieved through using various sensors including pH sensors, glucose sensors, turbidity sensors, and temperature sensors. Additionally, these sensors can be interfaced with a microcontroller. For instance, Arduino can be used in order to collect and transmit data into a cloud or mobile application. Such system is expected to enhance health monitoring as it will eliminate human error factor and allow monitoring patients' status in real-time.

In conclusion, it should be emphasized that the use of the Internet of Things in health monitoring has a huge potential in modern healthcare. Not only does it allow collecting and transmitting data in more efficient manner but also increases patient satisfaction and improves overall performance of health practitioners.

2. RELATED WORK

Several researchers have developed IoT-based healthcare systems for monitoring human health parameters. Most existing solutions focus on monitoring heart rate, body temperature, blood oxygen level, and blood pressure. Although these systems improve patient monitoring, they provide limited information regarding kidney function and urinary health. Previous studies on urine monitoring mainly rely on laboratory-based testing or urine test strips. While these methods provide accurate results, they require manual handling, trained technicians, and laboratory infrastructure. Such approaches are not suitable for continuous health monitoring or home-based healthcare applications. Recent research has introduced smart urine analysis systems using embedded sensors and wireless communication. These systems demonstrate the feasibility of measuring urine parameters electronically. However, many available systems are expensive, support only a limited number of parameters, or lack cloud-based monitoring features. Some systems also require complex calibration procedures and specialized hardware, reducing their practical usability.

The proposed Smart Urine Health Monitoring System overcomes these limitations by integrating multiple sensors into a compact IoT-enabled platform. The system provides simultaneous measurement of urine pH, temperature, and TDS while automatically transmitting data to the cloud through the Node MCU ESP8266. This approach improves portability, affordability, accessibility, and continuous health monitoring.

Table 1: Experimental Observations

Parameter	Normal Range	Sample Reading	Observation
pH	4.5 – 8.0	6.4	Normal
Temperature	35°C – 38°C	36.8°C	Normal
TDS	Depends on sample	580 ppm	Acceptable

3. PROBLEM STATEMENT

Urinary diseases and kidney-related disorders are increasing worldwide due to unhealthy lifestyles, dehydration, diabetes, and infections. Early diagnosis plays an important role in reducing complications, but regular laboratory urine testing is often expensive, time-consuming, and inaccessible for many individuals.

The major problems identified are:

- Dependence on laboratory testing for routine urine analysis.
- Delay in obtaining medical reports.
- High testing costs for frequent monitoring.
- Limited healthcare facilities in rural areas.
- Lack of continuous health monitoring.
- Manual recording of patient reports.
- Difficulty in remote health supervision.

To overcome these challenges, there is a need for a portable, IoT-enabled smart urine monitoring system capable of measuring essential urine parameters in real time. Such a system should provide accurate monitoring, cloud-based data storage, instant result display, and remote accessibility while maintaining low implementation cost.

4. PROPOSED SYSTEM

The proposed Smart Urine Health Monitoring System is an IoT-based healthcare solution designed to monitor important urine parameters

in real time. The system uses multiple sensors to collect urine sample data and processes it using a Node MCU ESP8266 microcontroller. The processed information is displayed on an LCD screen and simultaneously transmitted to a cloud platform through a Wi-Fi connection. Healthcare professionals and users can monitor the collected information remotely using a web or mobile application. The system is portable, cost-effective, and suitable for hospitals, clinics, diagnostic centres, and home healthcare environments. It helps users perform routine urine analysis without depending on laboratory facilities for every test.

A. System Components

Node MCU ESP8266: Node MCU ESP8266 acts as the central controller of the system. It receives sensor readings, processes the collected information, performs data validation, and uploads the results to the cloud using Wi-Fi connectivity.

PH Sensor: The pH sensor measures the acidity or alkalinity of the urine sample. Variations in pH values may indicate urinary tract infections, kidney disorders, dehydration, or metabolic abnormalities.

TDS Sensor: The Total Dissolved Solids (TDS) sensor measures the concentration of dissolved substances present in urine. Abnormal TDS values may indicate kidney dysfunction, dehydration, or electrolyte imbalance.

DS18B20 Temperature Sensor: The temperature sensor measures the sample temperature to ensure reliable sensor readings and identify unusual temperature variations that may indicate infection.

LCD Display: A 16×2 LCD is used to display real-time values of pH, temperature, and TDS immediately after measurement.

Cloud Platform: The measured data is uploaded to an IoT cloud server where it is stored securely. Doctors and patients can access previous reports for health monitoring and medical analysis.

B. System Architecture

The complete architecture consists of four major layers:

- Data Collection Layer: pH Sensor, TDS Sensor, and DS18B20 Temperature Sensor collect urine parameters.
- Processing Layer: NodeMCU ESP8266 processes sensor readings and filters invalid values.
- Communication Layer: Wi-Fi module transmits the processed data to the cloud server.
- Application Layer: LCD display, mobile application, and web dashboard present the results to users and healthcare professionals.

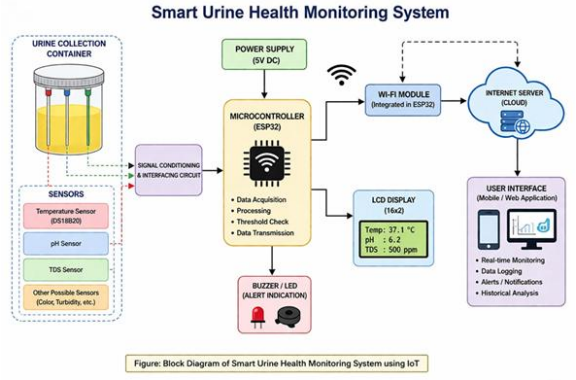

Figure 2: Block Diagram of Smart Urine Health Monitoring System using IoT

5. SYSTEM DESIGN AND METHODOLOGY

The methodology adopted in this research consists of hardware integration, software development, sensor calibration, cloud communication, and performance evaluation.

Step 1: Sample Collection
A fresh urine sample is collected in a clean container to ensure accurate measurement.

Step 2: Data Acquisition
The pH sensor, TDS sensor, and DS18B20 temperature sensor are immersed in the sample. Each sensor measures its respective parameter.

Step 3: Data Processing
The Node MCU ESP8266 reads analogy and digital sensor values, converts them into meaningful measurements, and removes unstable readings through software filtering.

Step 4: Display of Results
The measured values are displayed on the LCD screen within a few seconds, allowing immediate observation by the user.

Step 5: Cloud Transmission
The Node MCU establishes a Wi-Fi connection and uploads the measured data to the cloud platform. The uploaded information includes pH value, TDS value, temperature, date, and time.

Step 6: Remote Monitoring
Healthcare professionals can monitor patient reports remotely using the cloud dashboard.

Historical reports are stored for future comparison and disease analysis.

6. IMPLEMENTATION

The implementation of the proposed system includes both hardware and software development.

Hardware Implementation

The hardware setup consists of:

- Node MCU ESP8266 Microcontroller
- pH Sensor Module
- TDS Sensor Module
- DS18B20 Temperature Sensor
- 16×2 LCD Display with I2C Module
- Breadboard
- Jumper Wires
- USB Power Supply (5V)

All sensors are connected to the Node MCU according to their communication interfaces. The controller continuously acquires sensor readings and processes them in real time.

Software Implementation The software is developed using the Arduino IDE. Sensor libraries are integrated for accurate communication with the hardware devices. The program performs sensor initialization, calibration, data acquisition, cloud communication, LCD display control, and error handling. The cloud dashboard stores every reading with its corresponding timestamp, allowing users to review previous reports whenever required.

7. RESULTS AND DISCUSSION

The Smart Urine Health Monitoring System was developed and tested using a Node MCU ESP8266, pH sensor, TDS sensor, DS18B20 temperature sensor, and a 16×2 LCD display. Multiple urine sample measurements were performed to evaluate the stability and reliability of the system. The sensor readings were displayed locally on the LCD and successfully transmitted to the cloud platform through the Wi-Fi network.

The system responded quickly to changes in the measured parameters and maintained stable communication with the cloud server during testing. The collected data was stored with date and time information, enabling users to review previous records whenever required.

The experimental results indicate that the proposed system can successfully monitor important urine parameters in real time. The obtained values were consistent throughout repeated testing, demonstrating reliable sensor performance.

Discussion

The proposed system offers several practical advantages over traditional laboratory testing for routine monitoring. Since the device performs automatic data collection and cloud-based storage, it minimizes manual record keeping and enables remote health supervision.

The IoT-enabled architecture allows healthcare professionals to monitor patient data from different locations. The low-cost hardware makes the system suitable for deployment in homes, clinics, diagnostic centres, and rural healthcare facilities.

Although the prototype provides reliable measurements, its performance depends on proper sensor calibration and stable internet connectivity. Future improvements can include additional biosensors for glucose, protein, ketone, and creatinine detection to enhance diagnostic capability.

CONCLUSION

This research presented the design and implementation of a smart urine health monitoring system using IoT technology. The system integrates a Node MCU ESP8266 microcontroller with pH, TDS, and temperature sensors to provide real-time monitoring of urine parameters. The developed prototype successfully measures important health indicators, displays the results on an LCD screen, and uploads the information to a cloud platform for remote monitoring. The proposed solution is affordable, portable, and easy to operate, making it suitable for hospitals, clinics, diagnostic laboratories, and home healthcare applications. The experimental evaluation demonstrated that the system can perform continuous monitoring with satisfactory accuracy and reliable wireless communication. By enabling early detection of abnormal urine conditions, the proposed system has the potential to improve preventive healthcare and support timely medical intervention. Future enhancements may include machine learning techniques for disease prediction, integration with mobile healthcare applications, support for additional biochemical sensors, and improved cloud analytics for long-term patient health assessment.

ACKNOWLEDGMENT

The authors express their sincere gratitude to the Department of Computer Engineering and the project guide for their continuous guidance, valuable suggestions, and technical support throughout the development of this research work. The authors also thank the faculty members, laboratory staff, and project team members for their cooperation and encouragement during the implementation and testing of the proposed system. Their support played a significant role in the successful completion of this research.

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