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**Research Paper**

# Automated Bacterial Cleaning using UV Light with IOT Monitoring for Food Safety

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***Abstract—****The presence of bacteria in dairy and food processing environments poses significant health risks and requires stringent sanitation measures. This project introduces a UV-based bacterial cleaning system utilizing IoT technology to ensure effective disinfection and enhance operational safety. The system is powered by a reliable power supply and uses a NodeMCU microcontroller to manage and monitor the cleaning process. When the limit switch is activated, the NodeMCU triggers a relay module, which powers six UV LEDs positioned to target contaminated surfaces. The UV LEDs emit ultraviolet light, effectively eliminating bacterial contaminants. For added safety, the system includes a buzzer to alert personnel when UV sterilization is in progress, preventing accidental exposure. An LCD display, also controlled by the NodeMCU, provides real-time feedback on system status, such as power state and cleaning duration, allowing operators to monitor disinfection cycles easily. This IoT-based approach allows for remote monitoring and system integration into broader facility management platforms, optimizing sanitation in dairy and food processing plants. This innovation offers a reliable, automated solution for maintaining high hygiene standards, reducing bacterial contamination risks, and ultimately promoting safer food processing environments*

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## I. INTRODUCTION

Microbial contamination of confined spaces (e.g. public transport and hospitals) and frequently touched surfaces (e.g. elevator buttons, food contact surfaces, doors handle) is considered a global public health issue due to the potential for causing the spread of pathogens (Raeiszadeh and Adeli, 2020). Environmental contamination by pathogens has a significant impact on their transmission and spread, which in extreme situations, may contribute to pandemic scenarios. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic highlighted the importance of environmental disinfection in bustling indoor areas (Agarwal et al., 2021). Measures to prevent the spread of the virus have been adopted, in cluding social distancing, the use of protective face masks, and frequent handwashing. In addition, the use of traditional chemical disinfectants (i.e. ethanol, quaternaryammonium compounds and sodium hypochlorite) dramatically increased (Parveen et al., 2022). Despite being a strong strategy to inactivate microorganisms, continuous and repeated human ex posuretochemical disinfectants during the pandemic(mainly through der mal absorption and inhalation) has raised concerns about exposure-related long-term health risks (Dewey et al., 2022). Respiratory illnesses such as asthma and chronic obstructive pulmonary disease were associated with the massive use of traditional disinfectants. Moreover, bleach in combination with other household chemicals can cause the release of toxic gases (chlorine gas and chloroform) that if inhaled can cause severe respiratory disorders (Dewey et al., 2022). Nevertheless, besides the direct impact of chemical disinfectants, the negative impact of disinfection by-products (DBPs) cannot bedisregarded (Parveen etal., 2022).DBPs were already as sociated withcytotoxicityfor the humanliverandneuronalcelllines,geno toxicity, endocrine disruption, and carcinogenic effects (Parveen et al., 2022). Representative human health problems associated with exposure to DBPs are presented in Table 1 (World Health Organization, 2000). In addition to negative human health complications, the use of disinfectants and their DBPs can have adverse effects on the environment mainly in aquatic ecosystems, where they get into sewage and contaminate water resources (Dewey et al., 2022). Moreover, microorganisms can adapt and become tolerant to residual levels of disinfectants (Chen et al., 2021). The common bacterial tolerance mechanisms to disinfectants include mutation and horizontal gene transfer, upregulation of efflux pumps, membrane alteration, and biofilm formation (Chen et al., 2021). Acquired bacterial tolerance to benzalkonium chloride by Salmonella enterica, Pseudomonas aeruginosa, Enterobacter spp., Escherichia coli and Staphylococcus saprophyticus was already reported (Kampf, 2018). Moreover, chlorine-tolerant bacteria, such as species of Legionella, Sphingomonas,Mycobacterium, Bacillus,andPseudomonas have been the most reported in the literature (Luo et al., 2021). Increased bacterial tolerance to phenolic compounds, peroxyacetic acid, isopropanol, and hypochlorous acid was also reported (Nontaleerak et al., 2020). To overcome these problems, new alternative methods for disinfection have been implemented, particularly autonomous ultraviolet (UV)-based treatments (Bhardwaj et al., 2021)

## II. LITERATURE SURVEY

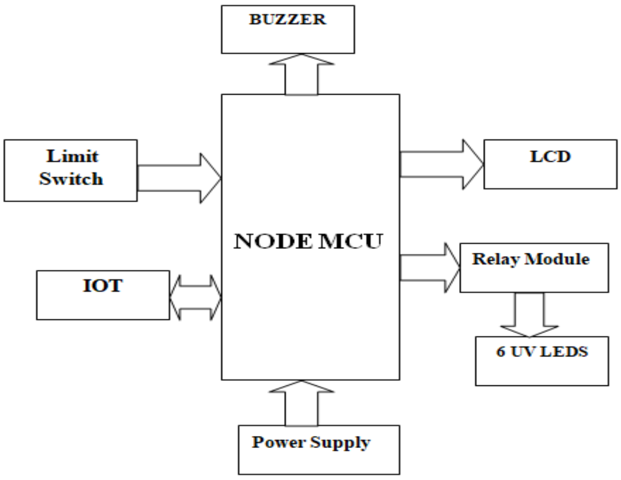
[1] This review discusses the practical applicability, validation requirements, and safety considerations of using UV disinfection for COVID-19 control, with a focus on addressing its limitations and potential risks by Milad Raeiszadeh& Babak Adeli, 2020.
[2] This study evaluates germicidal UV light's effectiveness in eliminating pathogens on surfaces, demonstrating its capability as a reliable disinfection method for public health by G. Katara, N. Hemvani, S. Chitnis, V. Chitnis, D.S. Chitnis, 2020.
[3] This project proposes an Arduino-controlled system for washroom sanitation, aimed at reducing manual cleaning efforts and improving hygiene in public spaces by Irene Maria Anto, Bibin Johnson, Febin Wilson, Fitha A. M. (UG students), Ambily Francis (Assistant Professor), 2020.
[4] This research presents a programmable UV disinfection device, which is low-cost and effective for room sanitization, aimed at minimizing pathogen spread in shared environments by Marcel Bentancor & Sabina Vidal, 2018.
[5] This article explains Arduino's working principles, its applications, and its utility as a tool for research and educational projects by Leo Louis, 2016.
[6] This study explores a method for PPE decontamination using UV in biosafety cabinets, addressing equipment reuse during shortages in the pandemic by Albert J. Fornace, Jr, 2021.
[7] This research introduces a UWB sensor for precise positioning, enhancing the effectiveness and safety of autonomous UV-C disinfection vehicles by Shih-Ping Huang, Jin-Feng Neo, Yu-Yao Chen, Chien-Bang Chen, 2021.
[8] This system integrates UV disinfection with temperature checks to mitigate COVID-19 transmission, offering a comprehensive public health solution by Avinash R., Dhanush R. T., Shashank B., 2021.
[9] This research introduces a UWB sensor for precise positioning, enhancing the effectiveness and safety of autonomous UV-C disinfection vehicles by Shih-Ping Huang, Jin-Feng Neo, Yu-Yao Chen, Chien-Bang Chen, 2021.
[10] This report highlights a UV LED solution capable of inactivating COVID-19 within 30 seconds, showing potential for rapid disinfection applications by Samuel K. Moore, 2020.
[11] This article reviews UV light's role in disinfection, particularly its ability to inactivate viruses, including SARS-CoV-2, in public health applications by Dana Mackenzie, 2020.
[12] This project introduces a smart tunnel using sensor-fusion for automatic disinfection, aimed at high-traffic areas to reduce infection spread by Sharnil Pandya, Anirban Sur, Ketan Kotecha, 2020.

## III.METHODOLOGY

### A. *Proposed Work:*

The proposed method introduces an automated, IoT-enabled UV disinfection system to enhance sanitation in dairy and food processing environments. This system is powered by aNodeMCU microcontroller, which serves as the central control unit for managing disinfection processes in real-time.When activated by a limit switch, the system uses a relay module to power six strategically positioned UV LEDs, ensuring broad surface coverage and effective bacterial elimination. A buzzer provides an auditory alert during disinfection cycles, enhancing personnel safety by reducing accidental UV exposure risks.Real-time feedback is displayed on an LCD screen, providing operators with essential information such as system status, cleaning duration, and cycle completion, thus improving operational visibility. The IoT integration allows for remote monitoring and control, making it possible to optimize cleaning schedules based on facility needs and sanitation requirements. This approach not only increases the reliability of bacterial disinfection but also minimizes human intervention, reducing the chances of error and ensuring residue-free sanitation. The proposed system aims to set new standards for hygiene in the food processing industry, offering a cost-effective, efficient, and adaptable solution for maintaining consistent cleanliness and safety.

*B. Block diagram*:




NODE MCU (ESP8266)

The NodeMCU is a low-cost microcontroller based on the ESP8266 chipset. It features built-in Wi-Fi connectivity, making it ideal for IoT applications. The NodeMCU is used to control and monitor the entire cleaning system, processing data and triggering actions based on sensor inputs and user commands. It communicates with other components (relay, limit switch, UV LEDs, LCD) via its GPIO (General Purpose Input/Output) pins. NodeMCU is programmed via the Arduino IDE and supports various communication protocols for remote monitoring and control, ensuring seamless integration with IoT-based platforms.

Specifications:

- **Microcontroller:** ESP8266 (Wi-Fi enabled)
- **Operating Voltage:** 3.3V
- **Wi-Fi Connectivity:** 802.11 b/g/n
- **Digital I/O Pins:** 9-11 (depending on model)
- **Analog Input:** 1 (0-1V range)

**Memory:** 4MB Flash

RELAY MODULE

A relay module is an electrical switch used to control high-power components using the low-power GPIO pins of the NodeMCU. In this project, the relay module acts as an interface between the microcontroller and the UV LEDs. When the NodeMCU triggers the relay, it powers the six UV LEDs, enabling the disinfection process. The relay is essential for handling the power requirements of the UV LEDs, as the NodeMCU itself cannot provide the necessary current.

Specifications

- Electromechanical switch to control high-current devices
- Can handle up to 10A at 250V AC or 30V DC depending on relay
- Triggered by low voltage 3.3V from the NodeMCU
- Optocoupler isolation for noise reduction and protection

UV LED

UV LEDs emit ultraviolet light, which is effective in killing or inactivating microorganisms, such as bacteria and viruses. In this system, six UV LEDs are strategicallyplaced to target contaminated surfaces and eliminate bacterial contaminants. The UV LEDs are controlled by the relay module, which is in turn triggered by the NodeMCU. UV-C light, in particular, is used for its germicidal properties, making it ideal for disinfection tasks in food safety environments

Features

- UV-C light emission, typically in the 200-280 nm range.
- High efficiency in killing bacteria and viruses.
- Low energy consumption compared to traditional UV lamps.
- Long lifespan and durability in harsh environments

LCD 16X2 DISPLAY

The 16x2 LCD (Liquid Crystal Display) is used in this project to display critical sensor data locally, providing real-time readings and system status for monitoring and alert purposes. Displays sensor outputs, such as pore water pressure, soil moisture, and water flow rate. Shows system alerts or warnings when critical thresholds are reached. Acts as a user interface for quick checks on the system's operation.

Specifications

- Dimensions: 16 characters x 2 lines
- Operating Voltage: 5V (commonly used with Arduino)
- Interface: Parallel (standard), I2C (for reduced wiring)
- Backlight: Typically LED backlight for visibility in dark environments
- Viewing Angle: 60°-90°

POWER SUPPLY

The power supply will supply the regulated power supply to the unit which is first converted into 12V AC. 12V AC is converted into DC using rectifier circuit.Finally, the 7805voltage regulator provides constant 5V DC supply which will be given to circuit.

Specifications:

Operating voltage -5V
Input voltage - 7-12V
Input voltage -6-20V
Digital I/O pins - 14(of which 6 providePWM o/p)

## IV IMPLEMENTATION

Power Supply:Provides stable voltage to all system components, including the NodeMCU, UV LEDs, LCD display, buzzer, and relay module.

NodeMCU Microcontroller:Acts as the central control unit, managing the cleaning process and ensuring proper operation of all connected components.

Limit Switch:Serves as a trigger for the system. When activated, it signals the NodeMCU to initiate the disinfection process.

Relay Module:Receives a control signal from the NodeMCU to switch ON/OFF the six UV LEDs.

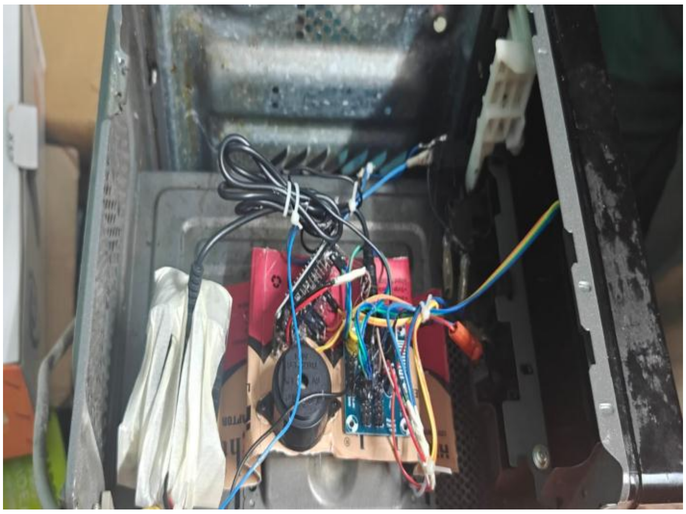
UV LEDs:Emit ultraviolet (UV-C) light to sterilize surfaces by eliminating bacterial contaminants.

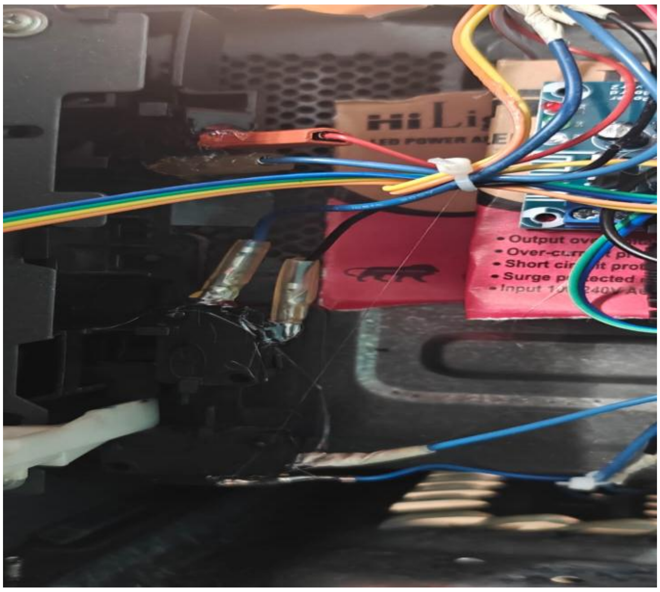
Buzzer:Alerts personnel when the UV sterilization process is in progress, ensuring safety by preventing accidental exposure.

LCD Display:Displays system status information such as power state, cleaning duration, and UV operation status.

IoT Connectivity:Allows remote monitoring and integration with facility management systems, enabling real-time status updates and control.

## V EXPERIMENTAL RESULTS





## VI CONCLUSION

The Automated Bacterial Cleaning System using UV light and IoT monitoring offers a reliable, efficient solution for maintaining high hygiene standards in dairy and food processing environments. By automating the disinfection process and integrating real-time monitoring and safety features, the system minimizes human intervention, ensures consistent sterilization, and reduces bacterial contamination risks. The IoT integration further enhances its capabilities, allowing for remote management and integration into larger facility management systems, ultimately contributing to a safer and more efficient food processing environment.

## References


[1]. Milad Raeiszadeh and Babak Adeli a Critical Review on Ultraviolet Disinfection Systems against COVID19 Outbreak: Applicability, Validation, and Safety Considerations MACS Photonics. 2020 Oct 14.

[2]. G Katara, N Hemvani, S Chitnis, V Chitnis, DS Chitnis, SURFACE DISINFECTION BY EXPOSURE TO GERMICIDAL UV LIGHT NIH, Mar 2020

[3]. Irene Maria Anto, Bibin Johnson, Febin Wilson, Fitha A. M. (UG students), Ambily Francis (Assistant Professor), Arduino-based Automated Washroom Sanitizing System IEEE Xplore July 2020

[4]. Marcel Bentancor , Sabina Vidal Programmable and low-cost ultraviolet room disinfection Device HardwareX Volume 4, October 2018, e00046

[5]. Leo Louis, "Working principle of Arduino and using it as a tool for study and research" IJCACS Vol 1, No2, April 2016

[6]. Albert J. Fornace, Jr, Georgetown UV decontamination of personal protective equipment with idle laboratory biosafety cabinets during the COVID-19 pandemic PLOS ONE, July 26 2021

[7]. Shih-Ping Huang, Jin-Feng Neo, Yu-yaochen, Chien-Bang Chen Ultra-Wideband Positioning Sensor with Application to an Autonomous Ultraviolet-C Disinfection Vehicle. Sensors ,1 August 2021

[8]. Avinash. R, Dhanush R T, Shashank B UV-C Disinfecting and Health Checkup System for Coronavirus , IJERT 20 July 2021

[9]. Jia Hu,JacobO'Brien,Ameya S. Joshi,Zahara Sadat Navabi, .Automated Device for Public Elevator Control Panel UVC Sanitization Design of Medical Devices Conference May 11 2020
[10]. Samuel K. Moore.Ultraviolet-LED Maker Demonstrates 30-Second Coronavirus Kill,IEEE spectrum, 16 April 2020
[11]. Dana Mackenzie,Elseveir Ultraviolet Light Fights New Virus Public Health Emergency collection, 27 June 2020
[12]. SharnilPandya,AnirbanSur,KetanKotechaSmart epidemic tunnel: IoT-based sensor-fusion assistive technology for COVID-19 disinfection International Journal of Pervasive Computing and Communications 31 August 2020.
[13]. Goda Vasantharao ,Sk Arifunneesa Temperature Detection and Automatic Sanitization and Disinfection Tunnel-COVID 19 The International journal of analytical and experimental modal analysis ,JUNE 2020.
[14]. Asif Ahmed, Mohd Noor Abdullah, IshkrizatTaib,Indonesian.Design of a contactless body temperature measurement system using arduino. Journal of Electrical Engineering and Computer Science, September 2020.
[15]. Nenad Petrovic and Dorde Kocic, IoT-based System for COVID-19 Indoor Safety MonitoringIcETRAN 2020, September 2020