A Contactless IoT-Based GPS-Tracked Waste Bin to Curb Medical Waste Infections in Ghana*

[1]J. K. Annan, [1]N. E. Akpeke, [1]E. A. A. Kwesi and [1]H. Appiah
[1]University of Mines and Technology (UMaT), P. O. Box 237, Tarkwa, Ghana

Annan, J. K., Akpeke, N. E., Kwesi, E. A. A. and Appiah, H. (2022), "A Contactless IoT-Based GPS-Tracked Waste Bin to Curb Medical Waste Infections in Ghana", *Ghana Mining Journal*, Vol. 22, No. 1, pp. 62-69.

Abstract

Irregular checking of waste especially in some medical facilities of Ghana leads to overflow of waste. A study by World Health Organisation (WHO) in February 2018 indicates that 15% of the total waste collected from medical facilities may be infectious, toxic, or radioactive and may contribute to unintended release of chemical or biological hazards. Considering the present COVID-19 pandemic and other diseases like ebola and hantavirus, it is critical to properly manage waste collected from medical facilities. In this study, Internet of Things (IoT) is used to design a smart bin to help reduce user contact to waste. Using a flowchart, a schematic model of the system was developed using Proteus 8.11 software. Two HCSR04 ultrasonic sensors were used to measure the waste level in the bin and detect proximity of objects to the bin to trigger an MG996R servo motor for automatic operation of the lid of the waste bin having a monitoring system. A NEO-6M GPS module was used to determine the location of the waste bin and displayed on a 16x2 LCD. A Graphical User Interface (GUI) was created for remote monitoring of waste over the internet. An ESP32 node MCU was programmed using Arduino software and used to interface the system with the GUI. The designed system was constructed and incorporated into a rectangular-shaped plastic bin. During testing, a hand wave at the sensor on the side of the container triggered opening of the bin. Sample waste placed in the bin were detected and real-time information regarding waste levels were sent to a self-designed HTML webpage called 'Smart Bin' with dynamic IP address. This system could be used in health facilities to prevent medical waste overflow, limit human contact to waste and avoid spread of infections.

Keywords: IoT, GPS Tracking, Waste Bin, Medical Waste, Ghana

1 Introduction

Waste refers to unwanted items that are usually discarded. Sources of waste include homes, schools, offices, hospitals, and industries. Waste can be categorised as being liquid, solid, organic, recyclable, or hazardous. Liquid waste includes organic liquids, waste detergents, and dirty water while solid waste consists of plastics, paper, cans, metals, glass, and ceramics. Some examples of organic waste are garden waste and kitchen waste whereas recyclable waste is usually solids that can be recycled, such as paper and metal. Hazardous waste comprises corrosive, toxic, flammable, or reactive waste (Anon., 2020). Other types of waste include agricultural and animal waste, municipal solid waste, medical waste, hazardous waste, industrial non-hazardous waste, construction and demolition debris, radioactive waste, extraction and mining waste, sewage sludge, oil and gas production waste, and fossil fuel combustion waste (Anon., 2018a).

In typical mining communities, like Tarkwa and Obuasi in the Western and Ashanti regions of Ghana in West Africa, several old buildings are compound houses that accommodate several tenants who presumably work in the mining companies. Most mining companies have hospitals or medical facilities to provide medical services to their workers. Diseases that are not typical of a particular community may be imported from expatriate workers who may leave traces of infectious hazardous waste at the hospital.

In Ghana, there is a high risk of cross-contamination from medical waste due to lack of thorough sorting of waste (Ohene Adu *et al.*, 2020), which may result in exposure to infections (Akum, 2014; Udofia *et al.*, 2018). Also, there is increased potential for the spread of infections and chemical pollutants due to open-fire pits and substandard incinerators used for burning infectious waste in some parts of the country (Ohene Adu *et al.*, 2020).

Without proper control of this waste at the hospital, other workers of the mining company, workers at the hospital facility, and members of the community who patronise the hospital could be infected due to the generic unkept infectious waste seen at the hospital. A typical infectious hazardous waste noted in a medical facility is shown in Fig. 1. This infection can quickly sweep within the mining company as well as the community since people in the community reside with the majority of the mine workers in compound houses.

*Manuscript received October 29, 2021
Revised version accepted June 27, 2022
https://doi.org/10.4314/gm.v22i1.8

Fig. 1 Image of Overflow Infectious Hazardous Waste

In this present era of infectious diseases like the novel COVID-19, Ebola, Swine Flu and Avian Influenza, which usually spread through contact of contaminated surfaces and infected persons (Karia *et al*., 2020; Judson *et al*., 2015; Kawanpure *et al*., 2014; Hayden and Croisier, 2005), waste collection at the various medical centres and other institutions like the research laboratories that produce infectious hazardous waste should be well controlled to reduce exposure, overflow, and contamination to the barest minimum. Consequently, safe and environmentally sound management of health care wastes can prevent adverse health and environmental impacts including the unintended release of chemical or biological hazards (Anon., 2018b).

1.1 Waste Management

Waste management methods consist of the following (Lumen, 2021):

(i) Prevention;
(ii) Minimisation;
(iii) Recycling and reuse;
(iv) Biological treatment;
(v) Incineration;
(vi) Energy recovery; and
(vii) Landfill disposal.

In order of preference, Lumen (2021) graded the waste management methods as being most favoured to least favoured as shown in Fig. 2.

Fig. 2 Grading of Waste Management Methods

Waste prevention is critical and usually requires attitudinal change and behavioural control (Corsini *et al*., 2018). Waste prevention and re-use are of high priority since they tackle the root causes of waste and usually take effect before a product expires or reaches its end-of-life (Barti, 2014). In all aspects of waste management, except prevention, effective waste collection is paramount for successful implementation of waste management strategies.

1.2 Waste Collection

Waste collection is the transfer of waste from usage or disposal points to treatment centres or landfill sites, usually through trucks, pipes or conveyor belt systems. Solid waste collection involves the accumulation of waste in polythene bags, metal, plastic, or concrete bins. Typical colour-coded waste collection bins for specific types of waste is shown in Fig. 3 (Anon., 2021a).

Fig. 3 Image of Specified Waste Collection Bins

1.3 Infectious Hazardous Waste

Infectious waste may cause human disease and may harbour pathogenic organisms, which may be detrimental to human health or the environment. Such types of waste should be properly collected, carefully transported or stored, well treated and residues appropriately disposed off. In medical centres, bins used to collect infectious waste are colour-coded particularly to separate sharp objects like needles and razor blades from blood-stained tissues and other organic tissues. Blackman Jr. (2001) admonished that people who handle hazardous infectious waste usually at the source of creation of the waste should be knowledgeable, provided with the necessary Personal Protective Equipments (PPEs), and well-motivated to help apply high safety standards.

2 Resources and Methods Used

This research involves the design of a waste bin system using IoT-based technology and having a GPS tracking system incorporated to allow for tracking of the bin when it is full and when it is being transported to treatment centres. The methods employed include the circuit design, selection of the components to aid in the build-up of the system, and the implementation of the system, which includes the operation and tracking. Further analyses were made with suggested mitigations of exposure, storage, and transportation issues at medical facilities in Ghana.

2.1 System Design

The design of the waste bin system considered three (3) main requirements namely:

(i) Contactless open and closure of the bin;
(ii) Continuous scanning to detect waste level and present location; and
(iii) Locked opening when full.

It was noted that focusing on the modification of the lid or cover of the waste bin could address the main issues required of the proposed bin. The intended operation of the waste bin is to automatically open the lid for the user to dump the waste when the user is within the range of a sensor and then close the lid with a possible locking of the lid to prevent further opening when the bin is full. Fig. 4 is a block diagram of the proposed design. It consists of a microcontroller, which with the help of an appropriate power unit processes input signals from ultrasonic sensors and GPS modules to help control a servo motor and then display the control information on an LCD with further transmission to a cloud server.

To provide for automatic opening and closure of the system, two ultrasonic sensors were employed. Sensor 2 (sub sensor) was placed outside the bin and programmed to respond to users within a specific range while Sensor 1 (main sensor) was placed inside the bin, specifically under the lid to detect waste level within a range that corresponds to the depth of the bin. To detect the present location, the GPS module was programmed to a cloud server using a temporarily generated IP address. Fig. 5 briefly describes the logical operating sequence of the system.

The bin is kept closed once there is no user within the triggering range of the subordinate sensor. The GPS module, which consists basically of a receiving antenna, calculates the bin's position using data received from GPS satellites. The GPS module sends real-time tracking location data in the form of latitude and longitude values to the node Micro-Controller Unit (MCU). The node MCU then sends the bin's fill level as well as its GPS coordinates to an internet portal (website) through a Wi-Fi transceiver for access by the waste management unit. To alert the user, the waste fill level is displayed on an LCD panel attached to the front of the bin.

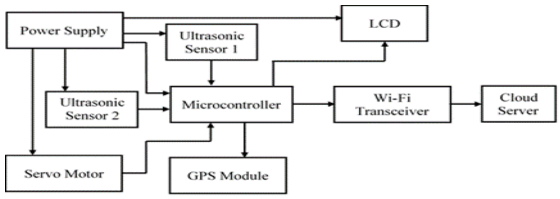

Fig. 4 Block Diagram of Design

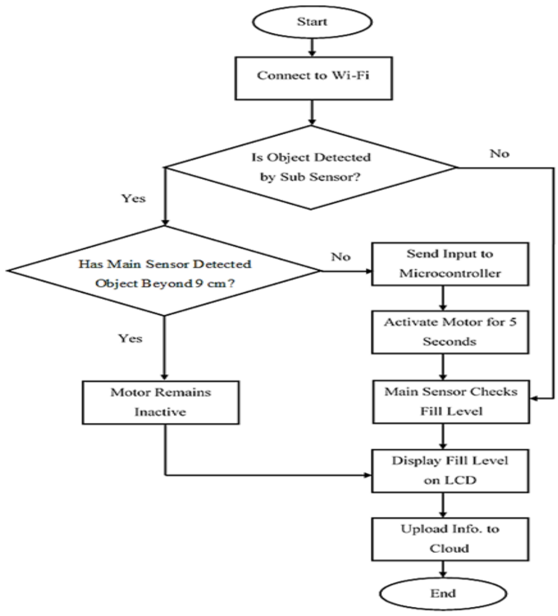

Fig. 5 Flowchart of Design

2.2 Component Selection

The components selected for the design include the following:

(i) A 5 V, 15 mA HC-SR04 Ultrasonic Sensor with an operating range of 2 cm to 400 cm and resolution of 0.3 cm (Fahad, 2020);
(ii) A 4-6 V, 5 kg, 0-180° holding position TowerPro MG996R metal gear servo motor with pulse-width modulation communication system, operating temperature range of +14 to +144 °F (-10 to +50 °C) and operating speed of 0.17 s/60° (4.8 V) (Anon., 2017);
(iii) A 5 V 30 mA blue and white coloured backlight 16×2 I2C Liquid Crystal Display (Akshay, 2020);
(iv) A 2.7-3.6 V, 45 mA, 50 channels NEO-6M Global Positioning System (GPS) Module (Anon., 2021b) with a horizontal position accuracy of 2.5 m and operating temperature of -40 °C to 85 °C; and
(v) A 5 V, 20 µA to 240 mA, 512 kB ESP32 SoC microcontroller with a maximum clock frequency of 240 MHz (Anon., 2021c).

For an ultrasonic sensor, the distance traveled by sound is calculated by Equation (1).

$$D = \frac{1}{2}T \times C \quad (1)$$

where, D = Distance being measured (m);
T = time for sound to be reflected (s); and
C = Speed of sound (m/s).

The speed of sound at sea level, assuming air temperature of 59 °F (15 °C), is 761.20 mph (340.29 m/s) (Howell, 2013). Given the operating range of 2 cm to 400 cm, the response time range for the operation of the selected ultrasonic sensor is determined as 1.18 ms to 23.51 ms.

Equation (2) describes how GPS calculates distance (Anon., 2021b).

$$\text{Distance} = \text{Speed} \times \text{Time} \quad (2)$$

where, Speed = Speed of Radio Signals (m/s);
Time = $T_2 - T_1$ = Signal Travel Time from the satellite to the receiver (s);
T_1 = Transmit Time of Signal from Satellite (s); and
T_2 = Receive Time of Signal at GPS Receiver (s).

To determine distance, both the satellite and GPS receivers generate the same pseudocode signal at the same time. The satellite transmits the pseudocode and is received by the GPS receiver. These two signals are compared and the difference between the signals then becomes the travel time. The receiver then calculates its location by using the Trilateration method when it knows the distance from multiple satellites and their locations (Anon., 2021b).

2.3 Modeling and Simulation

To aid in the simulation, various sections of the system were modeled. One of the sections was the power supply unit.

A model of the power supply unit adopted in the simulation is shown in Fig. 6, where a 240 V/50 Hz domestic supply is transformed to obtain a 5 V, 1 A output.

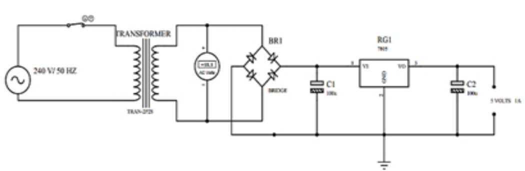

Fig. 6 Circuit Diagram of the Power Supply Unit

In its operation, the 5 V DC source supplies power to the entire circuit. The servo motor is connected to GPIO 16 (D0) of the Node MCU (Anon., 2021d). The sub and main sensors are connected to the Node MCU with their trig pins to GPIO 14 (D5) and GPIO 13 (D7), and echo pins to GPIO 12 (D6) and GPIO 15 (D8), respectively. The LCD SDA and SCL are connected to GPIO 4 (D2) and GPIO 5 (D1) of the Node MCU, respectively. RXD and TXD of the GPS module are connected to GPIO 0 (D3) and GPIO 2 (D4) of the Node MCU, respectively. The VCC of the GPS module was connected to the 3v3 pin on the ESP32.

Other units, including the GPS unit, cloud service, display unit, and the detection or sensor units, were programmed to respond to microcontroller I/O signals.

The schematic diagram of the system is shown in Fig. 7. The diagram is made up of a 5 V DC source, ESP32 Node MCU, servo motor, two HRS04 ultrasonic sensors, a 16×2 LCD, and a GPS module.

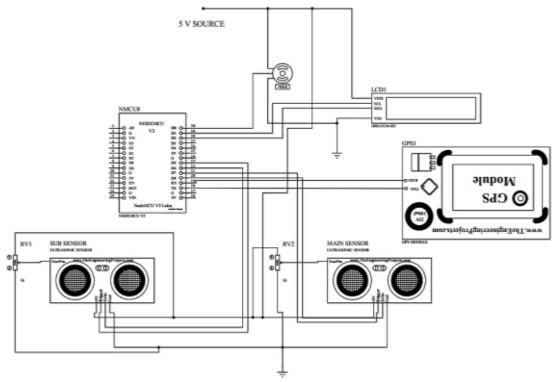

Fig. 7 Schematic Diagram of Proposed Design

The schematic diagram was designed using Proteus 8.11 software. After keen assessment of the pin connections, the Arduino IDE coding that linked the entire system was noticed to be error free. A webpage was then created using HTML creation software with a dynamic IP address of 192.168.137.97 to display the results of the filling process and the GPS tracking.

2.4 HTML Linkages and Arduino Coding Review

The design of the system consisted of HTML coding and linkages for monitoring of the progress of the system and Arduino coding for the control of the system.

The HTML linkages and Arduino coding requirements made use of the following header files and libraries.

(i) #include <Servo.h> // controls the TowerPro MG996R metal gear servo motor;
(ii) #include <Arduino.h> // contains supporting capabilities to execute the function;
(iii) #include <ESP8266WiFi.h> // connects the WiFi transducer to available WiFi network;

(iv) #include <Hash.h> // part of the esp8266 core for Arduino environment;
(v) #include <ESPAsyncTCP.h> // enables trouble-free multi-connection network environment for the WiFi transducer;
(vi) #include <ESPAsyncWebServer.h> // allows the setting up of an asynchronous HTTP (and Websocket) server;
(vii) #include <FS.h> // esp8266 core for Arduino environment;
(viii) #include <Wire.h> // allows communication with the I2C Liquid Crystal Display;
(ix) #include <LiquidCrystal_I2C.h> // controls the 16×2 I2C Liquid Crystal Display;
(x) #include <TinyGPS++.h> // controls the parameters of the NEO-6M GPS module; and
(xi) #include <SoftwareSerial.h> // allows serial communication on other digital pins of the Arduino.

The various stages of the Arduino coding included:
(i) Setting up of the GPS variables and objects using the TinyGPSPlus gps environment;
(ii) Initialising the GPS transmission variables for latitude, longitude and altitude values;
(iii) Coding the I2C variables and objects for the LCD;
(iv) Establishing the WiFi variables and objects uing the AsyncWebServer;
(v) Creating variables and ojects for the servo motor;
(vi) Coding and linking the ultrasonic sensor variables and objects;
(vii) Setting up of the global variables; and
(viii) Setting up of the GPS, LCD, Ultrasonic sensor, servo motor, SPIFFS, and WiFi parameters.

2.5 Implementation of the System

The build-up of the physical system was completed using a standard 23 litre waste bin with an average length of 28 cm, a width of 20.5 cm, and a height of 40 cm. The manufacturer design of the container determined the placement of the various electronic components on the container as shown in Fig. 8 and Fig. 9.

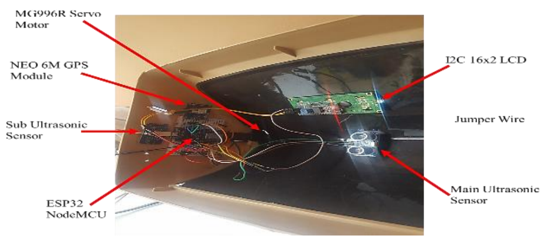

Fig. 8 Physical Placement of Components in the Lid of the Wastebin

Fig. 9 Image of the Prototype Built-Up System

3 Results and Discussion

The use of the ESP32 Wi-Fi module enabled the sending of information to the user through Wi-Fi Hotspot to an HTML website, which was accessed on a smartphone and a laptop computer using the dynamic IP address. The system indicated 'connect to Wi-Fi' on the LCD as shown in Fig. 10 when connected to a power source.

Fig. 10 LCD Notification on System Start-up

After a successful connection to the configured Wi-Fi hotspot, the waste level was indicated on the LCD and the website. Waste level in the container was determined every 2 seconds by the main ultrasonic sensor. The container lid was able to open automatically with the help of a servo motor when the sub-sensor was triggered and it closed after 5 seconds. During the filling of the container, a real-time information on the fill level was displayed in a graph form on the website and in percentage on the LCD as shown in Fig. 11. The phrase 'Sorry I am full' was displayed on the LCD when the sub-sensor was triggered while the container was already full as depicted in Fig. 12. The immediate filling of the waste bin produced the web display as shown in Fig 14. The coordinates of the location of the container were displayed on the website with the help of the GPS module (Fig. 13).

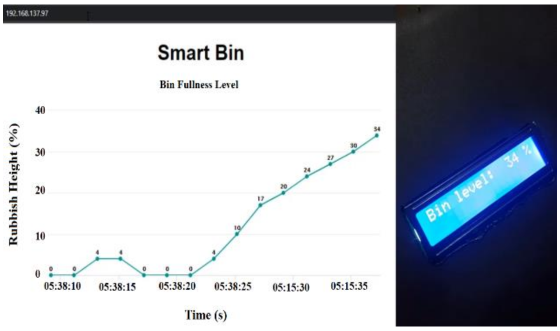

Fig. 11 Smart Bin Fullness Graph and Monitoring System Displaying Waste Level at 34%

Fig. 12 LCD Displaying Caution Message when Container was Full

The cost of purchase of the components employed in the design is summarized in Table 1. Components with serial numbers 1 to 6 were obtained from Aaenics online shop (Anon., 2021e). Component with SN 7 was obtained from Ransbet supermarket, which is a local store located in Tarkwa, Ghana.

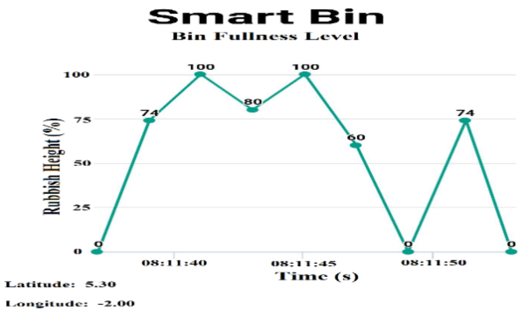

Fig. 13 Monitoring System Displaying Location of Bin with Waste Added and Removed

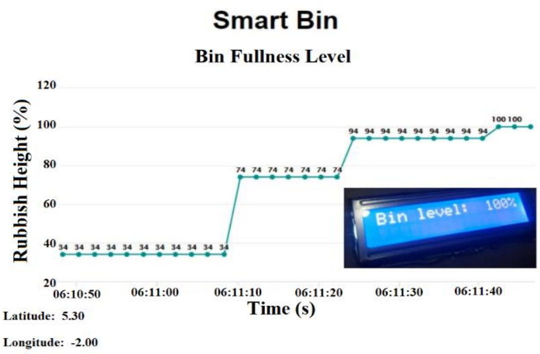

Fig. 14 Gradual Filling and Display of Waste Level Immediately Reaching 100% Full

4 Conclusions and Recommendations

With the design and construction of this and similar smart waste bins, medical waste can be well sorted, properly managed to prevent exposure and overflow, and safely transported to standard waste processing centres, which may be situated in remote areas or outskirts of the communities. Regarding the operation of the system, it was observed that the main sensor sometimes indicated that the container was full even when it was not full. This was due to unevenly distributed waste within the bin. It was also observed that the container lid continued to be in an open position when there was a power cut during the operation of the motor. In conclusion, the system opened automatically when the sub-sensor was triggered and closed after five seconds. The system remained closed when the bin was full. Real-time information on the system's waste fill status and the location was displayed on a website through a Wi-Fi connection. It is, therefore, recommended that multiple ultrasonic sensors could be used in mapping out the exact level of the waste within the bin. Also, the electronic components used could be well packaged and properly covered with waterproof casing to prevent damage by liquid waste. Finally, the system could be fitted with a battery pack to enable the standalone operation of the system and ensure safe transportation to waste processing centres.

Table 1 Cost of Implementing Proposed Design

SN	Component	Quantity	Unit Cost (USD)	Total Cost (USD)
1	ESP32 Module	1	4.87	4.87
2	GPS Module	1	7.30	7.30
3	Servo Motor	1	4.98	4.98
4	16 × 2 LCD and I2C	1	3.16	3.16
5	HCSR04 Sensor	2	1.14	2.28
6	Jumper Wires	40	0.04	1.60
7	Waste Container	1	4.87	4.87
Total				**29.06**

References

Akshay, J. (2020), "Interface I2C with Arduino Uno (Just 4 wires)", *https://create.arduino.cc/-projecthub/akshayjoseph666/interface-i2c-16x2-lcd-with-arduino-uno-just-4-wires-273b24*. Accessed: May 18, 2021.

Akum, F. A. (2014), "An Assessment of Medical Waste Management in Bawku Presbyterian Hospital of the Upper East Region of Ghana", *Merit Research Journal of Environmental*

Science and Toxicology, Vol. 2, No. 2, pp. 27-38.

Anon. (2017), "Towerpro MG996R Metal Gear Servo Motor", *https://www.inventelectronics.-com/product/towerpro-mg996r-metal-gear-servo-motor/*. Accessed: May 18, 2021.

Anon. (2018a), "Wastes: What are the Trends in Wastes and their Effects on Human Health and the Environment?", *https://www.epa.gov/repor-tenvironment/wastes*, Accessed: August 11, 2021.

Anon. (2018b), "Health-Care Waste", *https://www.who.int/news-room/factsheets/detail/health-care-waste*. Accessed: August 15, 2021.

Anon. (2020), "Know the Facts: The 5 Types of Waste and how to Remove it", *https:/-/www.newson6.com/story/5e8cf9a8fa8ed3749a62c805/know-the-facts:-the-5-types-of-waste-and-how-to-remove-it*. Accessed: July 10, 2020.

Anon. (2021a), "Rubbish Bins for Recycling Different Types of Waste", *istockphoto.com/-vector/rubbish-bins-for-recyclingdifferenttypes-ofwastegarbagecontainersvectorgm1092504754-293138771*. Accessed: June 21, 2021.

Anon. (2021b), "Interface Ublox NEO-6M GPS Module with Arduino", *https://lastminuteengin-eers.com/neo6m-gps-arduino-tutorial/.*Accesse-d: May 25, 2021.

Anon. (2021c), "Overview of ESP32 Features. What do They Practically Mean?", *https://www.exp-loreembedded.com/wiki/Overview_of_ESP32_features._What_do_they_practically_mean%3F*. Accessed: May 26, 2021.

Anon. (2021d), "ESP32 Pinout", *https://www.-exploreembedded.com/wiki/images/a/ac/ESP32_Pinout_a1_3.png*. Accessed: July 23, 2021.

Anon. (2021e), "Aaenics Shop", *https://aaenics.-com/shop*. Accessed: May 26, 2021.

Barti, A. (2014), "Moving from Recycling to Waste Prevention: A Review of Barriers and Enables", *Waste Management & Research: The Journal for a Sustainable Circular Economy*, SAGE Publications, Vol. 32, No. 9, pp. 3-18.

Blackman Jr., W. C. (2001), *Basic Hazardous Waste Management*, 3rd ed., CRC Press, Boca Raton, 488 pp.

Corsini, F., Gusmerotti, N. M., Testa, F. and Iraldo, F. (2018), "Exploring Waste Prevention Behaviour through Empirical Research", *Waste Management*, Elsevier Ltd., Italy, Vol. 79, pp. 132-141.

Fahad, S. (2020), "Smart Dustbin using Arduino, Ultrasonic Sensor, and Servo Motor*", https:/-/www.electroniclinic.com/smart-dustbin-using-arduino-ultrasonic-sensor-and-servo-motor/#-comments*. Accessed: May 17, 2021.

Hayden, F. and Croisier, A. (2005), "Transmission of Avian Influenza Viruses to and between Humans", *The Journal of Infectious Diseases*, Vol. 192, No. 8, pp. 1311-1314.

Howell, E. (2013), "What Is the Speed of Sound?", *LiveScience*, *https://www.livescience.com/37022-speed-of-sound-mach-1.html*. Accessed: June 12, 2021.

Judson, S., Prescott, J. and Munster, V. (2015), "Understanding Ebola Virus Transmission",-*Viruses*, Vol. 7, No. 2, pp. 511-521.

Karia, R., Gupta, I., Khandait, H., Yadav, A. and Yadav. A. (2020), "COVID-19 and its Modes of Transmission", *SN Comprehensive Clinical Medicine*, Vol. 2, pp. 1798–1801.

Kawanpure, H., Ugargol, A. R. and Padmanabha, B. V. (2014), "International Journal of Health Sciences and Research", Vol. 4, No. 8, pp. 6-11.

Lumen (2021), "Environmental Biology: Chapter 13: Solid and Hazardous Waste", *https://courses.lumenlearning.com/suny-monroe-environ-mentalbiology/chapter/15-2-waste-managemen-t-strategies/*. Accessed: May 12, 2021.

Ohene Adu, R., Gyasi, S. F., Essumang, D. K. and and Otabil, K. B. (2020), "Medical Waste-Sorting and Management Practices in Five Hospitals in Ghana", *Journal of Environmental and Public Health*, Vol. 2020, Article ID 2934296, 14 pp.

Udofia, E. A., Fobil, J. and Gulis, G. (2018), "Stakeholders' Practices and Perspectives on Solid Medical Waste Management: A Community Based Study in Accra, Ghana", *Journal of Environmental Protection*, Vol. 09, No.13, 19 pp.

Authors

J. K. Annan presently lectures at the Department of Electrical and Electronic Engineering of the University of Mines and Technology (UMaT), Tarkwa, Ghana. He holds PhD and degrees in Electrical and Electronic Engineering from the UMaT. He also holds a BSc degree in Electrical and Electronic Engineering from the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. He is a member of the Institute of Electrical and Electronics Engineers, International Association of Engineers and Society of Petroleum Engineers. His research interests are in Renewable Energy Systems, Reliability Assessment, Power Generation, Supply and Utilisation, Computer Applications and Control Systems.

N. E. Akpeke is an Assistant Lecturer in the Department of Electrical and Electronic Engineering, University of Mines and Technology (UMaT), Tarkwa. She holds a Master of Science (MSc) Degree in Electrical and Electronic Engineering (Power Systems) from the Pan African University Institute for Basic Sciences, Technology and Innovation (PAUSTI), Kenya. She obtained her Bachelor of Science (BSc) Degree in Electrical and Electronic Engineering from UMaT. She is currently a graduate member of the Ghana Institute of Engineering (GhIE). Her research interest areas are Power System Stability, Power Generation, Power System Protection, Power Transmission and FACTs Devices.

E. A. A. Kwesi is a Professional Land Surveyor and Consultant in Land Acquisition and Compensations and currently lectures at the Department of Geomatic Engineering of the University of Mines and Technology (UMaT), Tarkwa, Ghana. He holds an MPhil Degree in Mining Engineering from UMaT and a BSc Degree in Geomatic Engineering from the Kwame Nkrumah University of Science and Technology (KNUST), Ghana. He is a member of GhIS, GhIG, FIG, SME and GLP. His research and consultancy work cover Surveying and Mapping, Community Involvement and Multicriteria Decision Analysis and their applications in Sustainable Management of Land, Agriculture, Solid Waste and Community Development in Mining Areas.

H. Appiah is a graduate of the University of Mines and Technology (UMaT) and presently works with Nexans Kabelmetal Ghana Limited as a National Service Person. He holds a BSc degree in Electrical and Electronic Engineering from the University of Mines and Technology (UMaT), Tarkwa. He is a student member of the Ghana Institute of Engineering, UMaT Chapter. His research interests are in Computer Applications, System Automation and Control.