

IoT Based Waste Management System and Utilisation of Wet Waste to Generate Electricity

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ABSTRACT: All modernization and progress have had its share of disadvantage and one of the main aspects of concern is the pollution it is causing to the environment. With increase in the global population and rise in demand for food and other materials, there has been a rise in the amount of waste being generated. Thus, an effort to utilise this waste is introduced by creating a waste management system. The basis of this work involves identifying the garbage filled bins and models can be applied for a cleaner and greener initiative. This includes IOT based sensors that alert the central gateway when the garbage in the bin is excessively high and needs to be cleaned immediately. In a country like India, there are many places which suffer shortage of electricity to date. This project gives a solution to the present scenario by converting food/organic waste into electricity. Different combinations of Zn-Cu electrodes are placed in the semi-solid form of the food waste, resulting in an electrochemical reaction, hence converting chemical energy into electrical energy. With increase in the number of series and parallel combination of electrodes, the desired voltage and current can be obtained. Hence, the number of electrodes used is directly proportional to the resulting voltage and current values observed on the multimeter. Therefore, turning waste into energy can be one key to a circular economy, reforming the value of products, materials and resources.

KEYWORDS: IoT, Sensors, Identifying, Electrochemical, Electrode, Energy

I. INTRODUCTION

Many cities and towns in India need to undergo a change to develop further as smart cities and villages. It is identified by us that a wholesome effort is to be put forward in cleaning the garbage along the towns using electronic tools and government measures. These applications can be made possible with a revenue sharing model with IoT devices. It can integrate technology, property and communication to share information which will facilitate with many waste management processes. Due to rise of population among the cities and states, people face many problems like environmental issues with increasing garbage levels which eventually leads to spread of diseases and creates an unhygienic surrounding. Systematic management is required to avoid deadly diseases. The proposed system introduces an effective way of managing waste, by alerting the authority when the bin is full, thereby saving fuel, time, and also reducing the human effort. IoT permits all individuals and things to be smarter and more connected to the internet world. Facilitating new smart services and redesigning the active devices in smart cities are very effective, when we use IoT. Dynamic scheduling and collecting waste are the manual process, but can be done efficiently using IoT. There are two issues connected to the waste collection. First, how frequently do we collect waste from bins and secondly, how to inform this to the authority. The proposed system is self-aware and detects the level of the bin, sends an alert message to the authorities, so that they can make arrangements to replace the bin.

Here, our main focus is on the municipal dustbins placed outside every corner in the streets, since it accommodates all the waste. Other features of the system include an ultrasonic sensor, which is used for automatic opening and closing

flap of the bin in order to maintain a hygienic surrounding, thereby, avoiding the spread of disease. Another ultrasonic sensor is used to detect the level of the bin. LPC microcontroller board is used to send the information to a server. A power supply is used for the circuit. Population growth and rapid urbanization has had a huge impact on the waste generation. Increase in the global population and the rising demand for food and other essentials has led to a rise in the amount of waste being generated daily by each household. This waste is being recklessly dumped into villages. Everyday products that are used and thrown away are filled with hazardous and health-affecting chemicals. Indiscriminate dumping of waste contaminates surface and ground water supplies. The waste clogs the drain, creating a breeding ground for insects. Also, the uncontrolled burning and improper disposal aggravates air pollution. The present-day treatment of waste involves reducing the amount of waste, such as Compaction, Incineration, Pyrolysis, Gasification and Composting. Prevention of waste is a top priority when waste management techniques are concerned, but because this is humanly impossible for us with the lifestyles that we are used to, the next best is the recycling and reuse of materials. Another major part in this project involves the reuse of wet/organic waste into generating electricity. Food waste is taken in a grinded form, followed by an electrochemical reaction with the help of a pair of Zn-Cu electrodes. Thereby, the electricity generated can be stored and used for lighting up the street lights, etc.

II. RELATED WORK

As a major application field of IoT, waste management has been an issue. The absence of efficient waste management has caused serious environmental problems and cost issues. In this paper, an IoT-based Smart Garbage System (SGS) is proposed to reduce the amount of food waste. In an SGS, battery-based smart garbage bins exchange information with each other using wireless mesh networks, and a router and server collect and analyse the information for service provisioning [1].

One of the related papers proposes a solution to deal with unhygienic conditions created by waste overflowing. Cleaning of garbage bin at proper intervals will ensure proper cleanliness of the surrounding. But regularly manually monitoring the garbage level is a hectic job. Thus, to reduce the human effort a Smart Garbage Bin is introduced [2]. Another paper proposes a solution for the waste issues, converting food waste into electricity. The electricity is produced by the reaction between the electrodes with food waste as the medium. The principle used is conversion of chemical energy into electrical energy [3].

The key features of a smart garbage system inferred from the paper are- 1) Day to day monitoring and cleaning is helpful to keep the pollution minimal 2) Reduces human monitoring process 3) Minimizes the cost and time 4) System database can be accessed at anytime from anywhere [4].

A system using ARM7 Microcontroller, Ultrasonic Sensor, GSM and GPS is proposed for the efficient collection of the garbage. The GPS will show the location of the filled bin. The ARM7 Microcontroller takes the input which displays the required message on the LCD Display and hence sends a SMS to the concerned authority [5].

Another work shows how the garbage present in urban and rural areas leading to environmental issues can be managed and disposed efficiently. An additional key feature is a servo motor for an extra mechanism for closing of the trash bins, preventing spread of diseases [6].

III. METHODOLOGY

This section includes the methodology of the proposed system as shown in Fig 1. The block diagram of the proposed system consists of two major parts: first, to alert the authority to collect waste from the bin once its full and second, utilizing the wet waste to generate electricity. This system includes an automatic flap using Ultrasonic sensor (HC-SR04) that is attached to the flap of the bin, it senses the garbage in the hand of the subject and opens the flap automatically. This is done to avoid the overflow of the bin every time it has been used and also while it rains, hence to control the spread of deadly diseases. An Arduino UNO-R3 which is a microcontroller based on Atmega 328, supports this sensor where the software code is dumped. A Servo motor provides linear attenuation for the opening and closing of flap. Power supply of 9V battery is used. Next, is to detect the level of the garbage in the bin, another ultrasonic sensor attached to the bin senses the level of the garbage (when it reaches 90%) and alerts the authority through SMS. This sensor placed at a peak of the bin has an angle coverage of less than 15 degree, and ranging distance of about 2-500 cm. Four indicator LEDs indicate the level of the garbage at zero, level 1, level 2 and full. Once the LED indicates full, the next step is to alert the authority. To identify the location of the garbage bin, a GPS-VK16E with longitude and latitude global co-ordinates is used. A web page is created to provide the location of the filled garbage bin. An alert message is sent to the authority through an SMS which contain the details of the location. This is done by GSM/GPRS SIM800 modem, a class of wireless MODEM devices designed for communication of computer with the GSM and GPRS network. 16*2 LCD displays the status of the bin and modes in which the device is running. ARM7 microcontroller LPC-2148 controls the working of the system. Embedded C is used to code and Flash Magic is used to

run the software. The interfacing diagram is as shown in Fig 2. On receiving the text message, the authority can collect the waste from that particular location. Thus, this system results in efficient waste management. The second part of the project includes processing of the wet waste to generate electricity. The wet waste is further converted into semi-solid form. This process is carried out with the help of the grinder. It consists of DC motor, blades and switch. DC motor has high rpm which rotates the blades in order to process the wet waste. A pair of Zn-Cu electrodes are used. Zn electrode acts as an anode and Cu electrode as the cathode. This pair is dipped into the semi-solid form of waste. Hence, electrochemical reaction takes place on the semi-solid waste, resulting in conversion of chemical energy into electrical energy. A multimeter is connected to the electrode pair to observe the corresponding voltage. Experimentally it is observed that a single pair of Zn-Cu electrode produces a voltage of 0.84V and current in milli range. Increase in the number of electrode pairs and their arrangement is directly proportional to the corresponding voltage. It was also observed that as the surface area of the electrodes increases, more is the voltage irrespective of the quantity of waste. Hence this electricity produced is utilized to light up the LEDs.

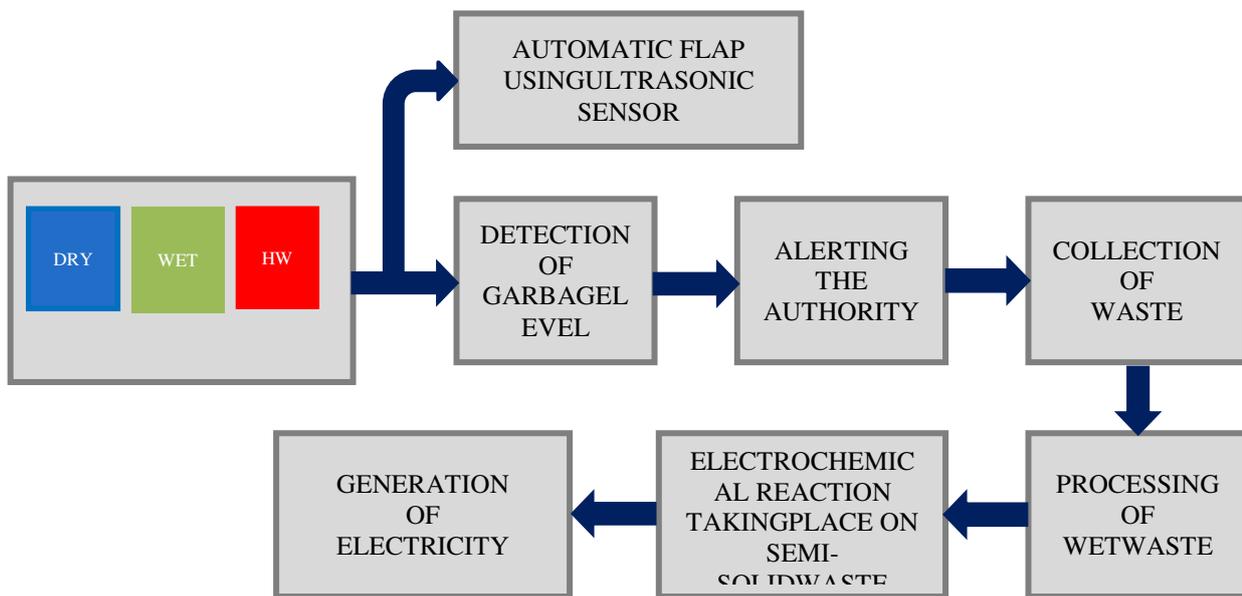


Fig 1: Block Diagram of the Proposed System

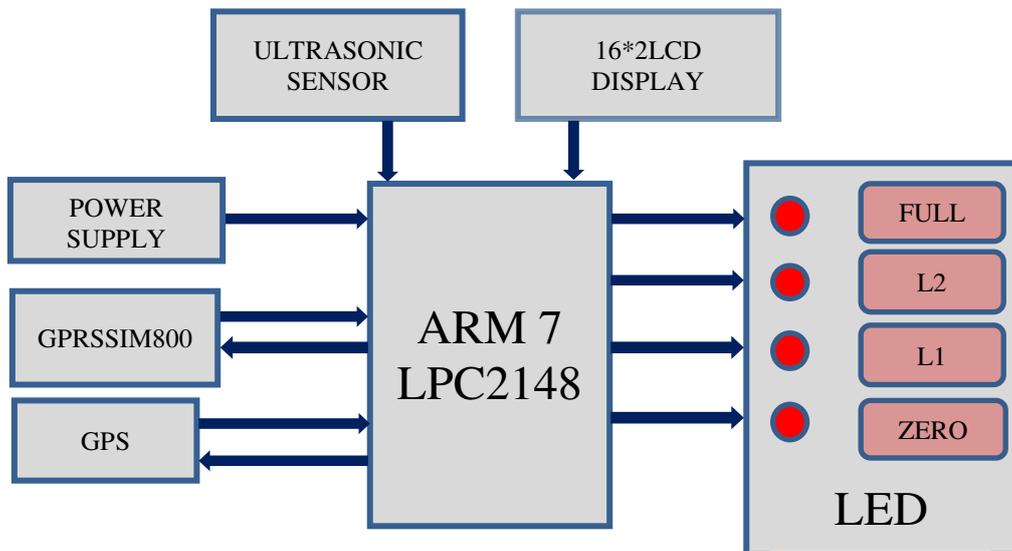


Fig 2: Interfacing Diagram

ULTRASONIC SENSOR (HC-SR04): Ultrasonic sensor is used to sense proximity and measure the distance to an object using ultrasonic sound waves. One of the most widely used models are HC-SR04.

ARDUINO UNO: It is an open-source microcontroller board based on Atmega328 microcontroller. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.

GPS-VK16E: The Global Positioning System (GPS) is a satellite-based radio navigation system. It provides geolocation and time information. GPS-VK 16E is a module kit suitable for Ultimate 1, Ultimate 2 and Ultimate 3 QRSS/WSPR kits.

GPRS/GSM SIM800: General Packet Radio Services (GPRS) is a packet-based wireless communication service that provides continuous connection to the Internet. It is based on Global System for Mobile (GSM) communication and complements existing services such as the Short Message Service (SMS).

ARM7 LPC2148: ARM (Advanced Reduced Instruction Set Computer (RISC) Machine) is a 32-bit processor architecture expanded by ARM holdings. LPC2148 is a 16-bit or 32-bit microcontroller based on ARM7 family. It has several in-built features and peripherals. On chip RAM is 8kB-40Kb, on-chip flash memory is 32kB-512kB, the wide interface is 128 bit and the accelerator allows 60MHz high-speed operation.

16*2 LCD DISPLAY: An LCD is an electronic display module which uses liquid crystal to produce a visible image. The 16x2 LCD display is a very basic module which displays 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5x7-pixel matrix.

SERVO MOTOR SG-90: A servo motor is an electrical device which can push or rotate an object with great precision. It is made up of a simple motor which runs through servo mechanism. It works on the PWM (Pulse Width Modulation) principle, which means its angle of rotation is controlled by the duration of pulse applied to its control PIN. The most commonly used servo motor is SG-90 which has a torque of 2.5kg/cm.

DC MOTOR, BLADES AND LEDs: DC motor transforms electric energy into mechanical energy in the form of rotation. A blade is the portion of a tool that is designed to slice or scrape surfaces or materials. A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it.

MAX 232: It is a dual transmitter/receiver that converts RX, TX, CTS, RTS signals. Max 232 is used to convert TTL voltage level to RS232 and vice-versa. It has capacitive voltage generator to supply RS232 voltage levels from a single supply of 5V.

Zn-Cu ELECTRODES: An electrode is a solid electric conductor that carries electric current into non-metallic solids, liquids, gases, etc. Electrodes are vital components of electrochemical cells. A simple electrochemical cell can be made from copper and zinc metals with solutions of their sulphates. In the process of the reaction, electrons can be transferred from zinc to copper through an electrically conducting path as a useful electric current.

IV. SOFTWARE REQUIREMENTS

ARDUINO IDE: The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software IDE, including complete error messages and other information.

HTML5: Hypertext Mark-up language used for structuring and presenting content on the World Wide Web. It is the latest and most enhanced version of HTML, used for front end technology. "Hypertext" refers to links that connects web pages to one another, either within a single website or between websites. HTML uses "mark-up" to annotate text, images, and other content for display in a Web browser.

CSS3: Cascading Style Sheets - style sheet language used for describing the look and formatting of a document written in a mark-up language. CSS3 is a latest standard of CSS, used for front end technology. CSS3 is used with HTML to create and format content structure. It is responsible for colours, font properties, text alignments, background images, graphics, tables, etc. It allows the designer to create websites, rich in content and low in code.

PHP: Hypertext Pre-processor - a server scripting language and a powerful tool for making dynamic and interactive web pages. It is used for back end technology. PHP code is usually processed on a web server by a PHP interpreter implemented as a module, a daemon or as a Common Gateway Interface (CGI) executable. The distinguishing feature of PHP is that the scripting code is executed on the server, which generates HTML that is sent back to the client.

MySQL: SQL is an abbreviation for structured query language. It is a standardized query language for requesting information from a database. SQL is used to communicate with a database. Every website is supported by a database at

the backend. Each time a user submits information or searches something in the website, data gets stored and retrieved from the database. SQL is the language for querying and storing data in the database. This database management system falls under RDBMS.

EMBEDDED C AND FLASH MAGIC: Embedded C is a set of language extensions for the C programming language by the C Standards Committee to address commonality issues that exist between C extensions for different embedded systems. It is used to program the code for the LPC2148 microcontroller. Flash Magic is a PC tool for programming flash-based microcontrollers from NXP using a serial or Ethernet protocol while in the target hardware. This tool helps the developer to easily burn the hex file generated by the embedded software like Keil μ vision.

KEIL MICRO VISION:It is a software development environment for a wide range of Arm Cortex-M based microcontroller devices. It is an IDE, which integrates a text editor to write programs, contains a compiler and converts source code to hex files. μ Vision offers a Build Mode for creating applications and a Debug Mode for debugging applications. The μ Vision IDE combines project management, run-time environment, build facilities, source code editing, and program debugging in a single powerful environment.

V. EXPERIMENTAL RESULTS AND DISCUSSIONS

Garbage level is indicated depending on the lighting up of LEDs on the dustbin; once the bin is full, the topmost LED lights up and an alert message with the Google maps location link of the dustbin is received by the authority. The dustbin flap opens automatically when the ultrasonic sensor senses the garbage. Once the garbage is dumped in, the flap closes automatically. The processor grinds the collected wet/food waste and converts it into a semi solid form for further utilisation. Zn-Cu electrode pair is dipped into the semi-solid waste obtained which lights up the LED due to the electrochemical reaction, thus producing electricity. The following scenarios were observed when the experiment was conducted:

Scenario1:

When garbage is dumped into the dustbin the level is indicated by the LEDs as shown in Fig 3: When bin is empty (0%), the first LED lights up (EMPTY). When garbage level is around 30%, second LED lights up (LEVEL 1). When garbage level is around 50%, third LED lights up (LEVEL2). When bin is full (90-95%), last LED lights up (FULL).



Fig 3: Garbage Level Indication

Scenario2:

Fig 4 shows that once bin is full, last LED (FULL) lights up and an SMS is received by the authority immediately. The SMS contains the link to the Google map location of the filled dustbin as shown in Fig 5.

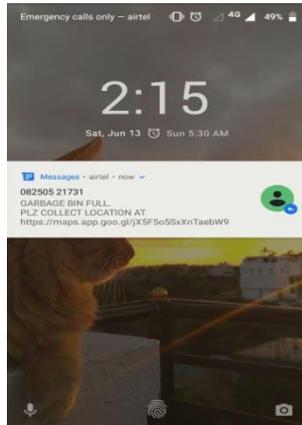


Fig 4: SMS received by Authority

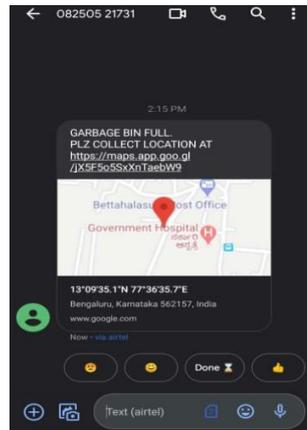


Fig 5: Google Map Location

Scenario3:

The flap of the bin automatically opens and closes (Fig 6) on sensing the garbage. The collected wet waste is transferred to the processor (Fig 7) which converts it into a semi-solid form for further utilisation.



Fig 6: Automatic Flap



Fig 7: Processor

Scenario4:

The electrodes are dipped in the semi solid waste and the following observations are made: 1) One pair of Zn-Cu electrode is dipped into the semi-solid waste; the multimeter is connected to the electrodes and the corresponding voltage obtained is 0.84V as shown in Fig 8. 2) Two pairs of electrodes are connected to a digital watch (Fig 9); the watch starts working 3) Two pairs of electrodes lights up one LED (1.2-1.3V) and four pairs of electrodes lights up two LEDs (2.1-2.3V) as shown in Fig 10. Thus, as number of electrode pairs increase, the voltage increases and hence more electricity is produced.

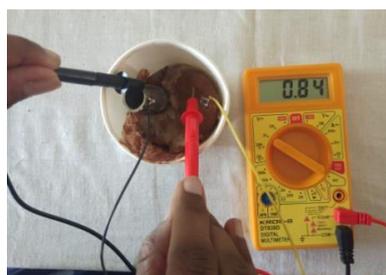


Fig 8: Voltage Reading for one pair of Zn-Cu Electrode



Fig 9: Working of a Digital Watch



Fig 10: Lighting up of LEDs using two and four electrode pairs respectively

VI. CONCLUSION

Thus, through this project we intend to propose a technological process for waste management system, starting from smart waste collection to waste utilization. This IoT based system assures the cleaning of trash bins as soon as the garbage level reaches its maximum, reducing the total number of trips and hence reducing the overall expenditure associated with it. Thus, it contributes towards keeping the society clean. Waste utilization can be implemented by using the wet waste to produce electricity instead of dumping it in landfills which are a threat to the environment. The electricity produced can be used to light up street lights especially in rural areas. It can also be stored in batteries and be used for various other purposes. The experiment shows that as the number of electrode pairs increase, the electricity generated also increases. The graph shown in Fig 11 shows the relationship between voltage reading and number of electrode pairs. Overall, this project aims to provide a solution to few of the existing problems faced by the environment and the society using a system which runs on one of the booming technologies. The proposed system is easily accessible and cost effective and works towards the well-being of all, the nature and the living.

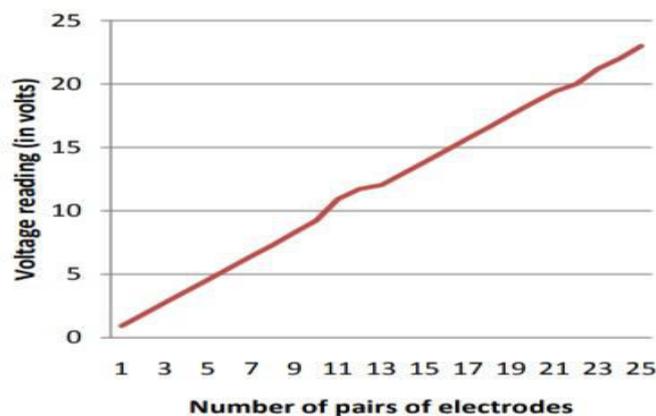


Fig 11: Voltage Reading vs Number of Electrode Pairs

VII. FUTURE SCOPE

It contributes towards Swachh Bharat Abhiyan and enhancement of a smart city vision. E-Dustbins can be further implemented with a compressor to store more garbage in a single bin. It can be taken to product level and made durable by making it compact and cost effective. It thus reduces health risks as well as provides electricity. The electrical energy generated from waste can be stored in batteries and further utilized for various purposes. Large electrochemical cells can be used in factories to process huge quantities of wet waste for generating and storing electrical energy. Municipal Corporations can take it as a compulsory initiative to avoid dumping in landfills. It is advantageous over other methods of electricity generation (for example, incineration and biogas plants). It is cost effective, has no contribution to pollution and huge machinery is not required; modifying it for large-scale use is easier and economical considering the present crisis due to Covid-19.



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