COVID-19 Waste Management System

H Prathiba
School of Computer Science and Engineering
Vellore Institute of Technology
Chennai, India
Email: prathibaright151@gmail.com

***Abstract*— Effective Waste management plays a vital role in having cleaner environment. COVID-19 Pandemic has increased the amount of waste generation as each individual may require personal safety equipments to protect them. Face masks are the most commonly used equipment today. Used masks can be found in common bins and roads, which is a threat to safe environment as they may enable further spreading of infection. Today, billions of masks are used and disposed globally. This project aims to develop a smart and safe bin for disposal of masks using IoT. The objective of the smart bin is to collect masks and give a sanitized output by disinfecting methods like UV sterilization and incineration. The smart bin consists of height sensor and weight sensor which are attached to Arduino board. When the bin reaches its threshold value, the collected masks are disinfected and can be collected safely reducing further transmission through the waste. It also reduces the risk of person getting infected during collection of waste. Real time progress can be tracked for timely clearing, promoting safer environment.**

***Keywords*— Waste Management, COVID-19, IoT, Arduino, Sensors, Smart bin, Face masks.**

I. INTRODUCTION

Waste management plays a vital role in having cleaner cities. COVID-19 pandemic has created a new normalcy of wearing safety equipments like masks, gloves, PPE'S etc. The amount of waste generated before and after pandemic has drastically changed. In China, Wuhan, the amount of waste generated before pandemic was 40 tonnes per day and after pandemic was 247 tonnes per day. COVID-19 waste is highly infectious and person handling the waste is susceptible to infection.

Wearing of masks in public was mandated by WHO, to reduce transmission. Today, the number of masks used and disposed, accounts to billions, globally. Not only medical professionals, even common man has to wear safety equipments. Therefore, General purpose waste needs to be treated with care as it may be a potential source of infection. Also, used masks are the most commonly found trash in public bins and roads. These used masks can act as source of transmission and can cause further spreading if not disposed properly.

This paper proposes ideas to link safe waste collection with IoT. Internet of Things with internet gives smart solutions like smart homes, smart parking methods to simplify complex tasks. The key idea is to make the bin sense when it is full and treat the contents in the bin with a disinfecting method. Ultrasonic sensor is used to measure the capacity of the bin. When the bin is full the waste needs to be treated by disinfecting it. After disinfection a message is sent to corporate personnel for timely collection of the safe waste. The collected masks can be disinfected either by UV light penetration or by passing the collected masks to an incinerator which burns the masks into ash. By this the person collecting the output waste can safely collect it without being infected.

A. UV Light sterilization

Ultraviolet sterilization is process of using short-wavelength UV-C light for killing microorganisms over surfaces by destroying their nucleic acid. UV-C is category of Ultraviolet light with wavelength of 200-280 nm which can inactivate virus, bacteria and fungi. But UV-C is harmful for the skin. Another category of Ultraviolet light is the Far-UV which has a wavelength of 222 nm and is comparatively less harmful to the skin. Far-UV has proven to kill 99.9% of corona virus on surfaces when exposed for 25 minutes.

B. Incinerator

Incineration is a process used for treating which involves the combustion of waste in presence of oxygen at temperatures above 800˚C.It is also described as Thermal treatment where waste materials are burned and converted into ash. An incinerator consists of three fundamental parts as listed below:

(i) Heat chamber
(ii) Ash tray
(iii) Chimney

The heat chamber contains plates or rods for heating the furnace. Combustion waste occurs in the heat chamber The waste content at a very high temperature burns into ash. The ash deposit is collected in ash tray. The smoke produced in the process is let out through chimney. Collection and transportation of ash is much easier and safer.

The rest of the paper is divided as follows: Section II covers related works. Section III explains the problem statement. Section IV explains about proposed systems. Section V is the conclusion. Section VI contains references.

II. RELATED WORK

Waste management is still a challenge in many of the developing countries. In the times of pandemic even general waste materials needs to be handled with care as it may carry viruses and cause further spreading. Many papers have proposed various approaches in terms of waste management, waste transportation, waste segregation, route optimization for trucks and so on. Ultrasonic sensor played a key role in

most of the proposed approaches. Ultrasonic sensor also called as height sensor is used to measure the capacity of the bin, i.e. detects whether the bin is full or not. The sensor detects when the bin is full and sends the data to corporation personnel, notifying them.

In paper [1] an automated waste collection system was developed which alerts authorities when bin gets filled and has buzzer that alarms when garbage is detected around the bin by IR sensor. Additionally, the bin remains closed in case of rain as rain sensors help in detecting presence of rain. This system used SPI Ethernet shield for sending and receiving of data. In paper [2] An IoT system with height sensor, weight sensor and MQ gas sensor was developed using Arduino and Raspberry Pi. The unique feature in this system was to compress light weight waste materials present in the bin using load cell thus creating space for additional waste storage. Data was backed up in ThingSpeak cloud platform. In paper [3] an automated system that monitors the bin level and also detects toxic gases emitted in the bin, was developed using IoT and GSM/GPRS module for wireless communication. The GSM module sends messages over mobile network.

In paper [4] RFID technique was used to enhance the waste management process. RFID tag helps to verify whether bin is emptied by the truck driver. RFID technique involves two components, RFID tag and RFID reader. RFID reader continuously emits Radiofrequency waves. When an object with RFID tag is detected, the RFID tag sends feedback signal to reader. In paper [5] A waste management system with LoRa protocol and TensorFlow deep learning model was proposed. The distance between waste deposit and collection point matters for effective signal communication. LoRa is a low power, WAN protocol that aids long range communication. An object detection model was developed using TensorFlow framework. The bin was divided into four compartments for collecting different types of waste like plastic, metal, paper and other general waste. The type of waste was identified using image processing. This was achieved with help of dataset populated with many images of waste materials. In paper [6], it mainly focuses on classification of waste based on images. Various fusion models were studied and performance of each deep model was analysed. The paper gives an analysis of multiple deep models used for image processing by extracting features of images. Capabilities of early and late fusion models were combined to develop an improvised image based waste classification process. In paper [7] the aim was to find an effective route for trucks. Historical data of generated waste was collected and analysed to predict the behaviour of people about their waste disposal trends. Objective functions to select an optimized route where defined based on two factors: (i)The amount of waste to be collected should be maximum. (ii)The distance covered by truck should be minimum. Based on this route optimization is done.

In paper [8] a framework of various IoT systems designed for various services needed in an urban area is given. A smart city needs services like air quality monitoring systems, waste management systems, traffic control etc. All smart city services work on a centralized urban IoT architecture consisting of three functional layers which are (i) Data layer (ii) Transport/Application layer and (iii) Network layer. A study of Constrained and unconstrained technologies are discussed for selecting a good communication technique for IoT system. In paper [9] a survey of opportunities and challenges of different waste management models with ICT is discussed. Waste management systems with a combination of various sensors like height, weight, gas, temperature, pressure, humidity and other technologies like RFID, WSN's and actuators was analysed to develop a better and efficient waste management system using IoT. In paper [10] a robust way of automated waste management using cloud computing paradigm is proposed. Waste collection, disposal and route for trucks are supported by cloud. In this system, separate bins for organic and inorganic waste are placed where each bin is connected to the cloud. The pre-separated waste percentages in each bin are updated, enabling timely collection and efficient route for truck drivers. In paper [11] a UV bot with three UV lamps that emits UV-C light was built to disinfect surfaces. It is equipped with camera and ultrasonic sensors for detecting any obstacle in its path and moves accordingly. Raspberry Pi was used as the microcontroller. A Website is developed for controlling the UV bot via Wi-Fi, for turning it on/off and decreases or increases its speed. The UV bot was tested against sample plates with S.Aureus bacteria, which were placed 35cm away from the bot resulting in complete elimination of bacteria within 8 seconds. In paper [12] the paper proposes a incineration methodology. The system consists of bin attached with incinerator. Further it contains height sensor to check whether bin is full, a heat chamber for combustion and chimney for ventilation. It is eco-friendly as a filter is attached in the chimney. Also it is portable as wheels are attached to the incinerator. Residues with unburned napkins are re-burned in the second process of incineration. The outcomes of incineration of waste are given below:

(i) At a temperature above 800 centigrade, waste was burned into ash.
(ii) Incineration decreases the amount of waste by 80 to 90%.
(iii) Ash can be carried with ease.
(iv) Compared to solid waste more amount of ash can be transported.
(v) Doesn't give rise to bad odour.

In paper [13] a study of different types of waste, and respective methods to be adopted based on the type of waste is made. Different types of incineration are discussed. The paper also focuses on the development of low cost incinerator and its effective usage for various waste materials.

III. PROBLEM DEFINITION

In this pandemic more amount of waste is being generated due to everyday usage of safety equipments. Waste management plays a vital role in having cleaner cities. Also,

COVID-19 waste is highly infectious and person handling the waste is susceptible to infection. Face masks are commonly used by many people. Used masks if thrown in public bin may give rise to further transmission, as they may carry viruses or bacteria if the person who used it is infected. Further masks can be bio-degradable or non-biodegradable based on the material with which they are made of. There is a necessity to handle masks carefully to reduce threat to environment. In order to collect and handle masks safely this paper proposes a smart bin system for collecting and disinfecting masks.

IV. PROPOSED SYSTEM

In this paper two approaches for developing smart bin system to collect masks are suggested. Both the approaches uses ultrasonic sensor for measuring the level of waste present in the bin. An ultrasonic sensor consists of two parts a transmitter and a receiver. The distance of the object detected can be calculates using the time taken by sound wave to travel between sensor and destination object. The following formula is used to measure the distance.

Let d be distance, s be speed and t be time taken

$$s = \frac{d}{t}$$

Here, the speed is considered as speed of sound which is 340.29*m/s*. The distance between sensor and destination object is

$$(2 * d) = (s * t)$$

After collection of waste masks, the two proposed approaches follow either of the process given below:

- UV disinfection
- Incineration

A. UV Disinfection

This process focuses on developing a smart bin for disposal of face masks with a sanitizing module for sanitizing the masks present in the bin. The sanitizing module is a UV lamp that is placed under the lid. The working can be categorized into three layers which are 1) Perception layer 2) Network layer 3) Application layer.
1) Perception Layer: Identification of masks by the sensor. Ultrasonic sensor measures the level of waste and weight sensor can be used to make accurate estimation of amount of masks collected in the bin.
2) Network Layer: Transmission of collected data. Involves sending of notification when the bin is full.
3) Application layer: Analysing and storing of real time values through a web page.

Arduino UNO board is used as a microcontroller. Based on the level of waste the UV module needs to be activated. When the bin if half filled, UV module is set on. Again when the bin is completely filled, the UV module is set on This ensures that emitted light waves penetrate through all the masks present in the bin. Since masks are lightweight materials weight sensor can be used to cross check amount of masks present.

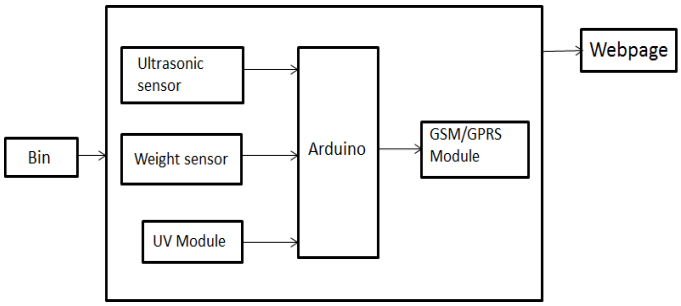

Fig.1 Block diagram of proposed system with UV module

After UV module is set on for certain time period, a message is sent to notify sanitization is completed. The authorities can then be notified that sanitized waste can be collected.

B. Incineration

Incineration is the combustion of waste in presence of oxygen at a temperature above 800˚C. This process aims to develop a smart bin for disposal of masks with an incinerator attached to the bin. When the bin collects a certain amount of masks, the incinerator burns the masks and converts it to ash promoting safe waste collection.
In this system the smart bin is responsible for collecting masks and the incinerator is responsible for combustion of masks. A case study of an Incinerator named EasyBurn, responsible for burning of napkins is given below:

TABLE 1. Case study of EasyBurn incinerator

Key elements	**Description**
Construction	Made with epoxy coated metal
Heating Base	Stainless steel
Working temperature	350˚C-500˚C
Ash Collection	Insulated ash tray.
Capacity	50 per day
Air control	Vent at bottom and top
Power	220/240 V
Burning time	10-15 minutes

In the proposed model, Ultrasonic sensor detects when the bin is completely filled. When the bin is full, the valve attached in between the bin and incinerator is opened

automatically with help of motor. The collected masks fall into the incinerator. The incinerator has three parts: 1) Heat chamber 2) Ash tray and 3) Chimney.

1) Heat chamber: It is responsible for heating the furnace. The chamber contains heater rods or plates for producing heat. The masks are burned in this chamber.

2) Ash Tray: The masks are converted to ash after combustion. Ash tray is used for collecting ash deposit after combustion.

3) Chimney: During combustion smoke is released. Chimney conducts the gases released in the furnace.

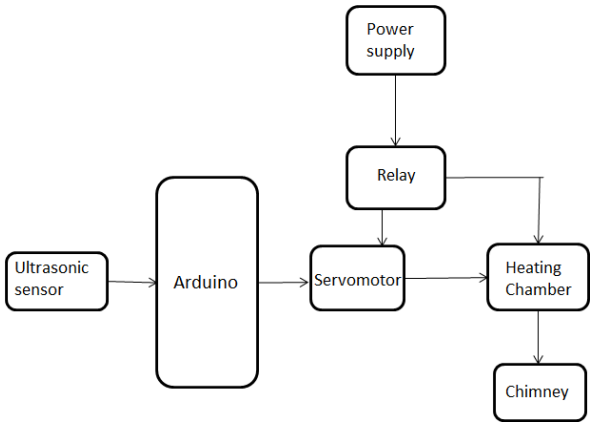

Fig.2 Block diagram of proposed system with Incinerator

Incineration at high temperatures kills microorganisms. Direct contact with the used masks can be avoided by this method as only ash tray needs to be emptied. Ash is safer to handle and easier to transport.

V. CONCLUSION

The proposed system helps to manage huge amount masks used every day. Person collecting the waste containing used masks is vulnerable to diseases. This can be avoided with proper treatment of masks collected in the bin. UV light helps in eradicating microorganisms present over the surface. Masks can be safely collected. Incineration is also useful reducing the amount of waste to be collected and transported. IoT helps in integrating sensors and modules to develop an automated waste management system which also reduces manual effort and promotes healthy society.

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