

SMART WASTE MANAGEMENT WITH 100% DOOR-TO-DOOR WASTE COLLECTION USING IoT

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ABSTRACT:

The management of solid waste is an issue that concerns everyone in the globe. Waste and consumption management decisions made by individuals and governments have an impact on the everyday health, productivity, and sanitation of communities. Poorly managed waste is harming wildlife that consume waste unknowingly, polluting the oceans, cluttering drains and causing flooding, breeding disease-carrying vectors, increasing respiratory problems due to airborne particles from burning waste, affecting economic development through decreased tourism, and more. There is an urgent need for action at all levels of society to address the unmanaged and badly managed trash from decades of economic growth. The Governments in many developing countries are making desperate efforts at National Level, State Level, and Municipal levels to make this waste management a simplified process and will make this universe free from dumping waste at any location. In this paper, we'll talk about a smart trash management system that was created with help of the Internet of Things (IoT), raising citizens' awareness of garbage management. An effective method for waste management will be implemented thanks to the automation of the entire system. For applying this IoT-based system, we have chosen Pune City where we will be experimenting with this system with a joint venture with Pune Municipal Corporation. The advantages of our system over the other similar system are that we had considered all the entities into consideration for waste management which includes the household, waste picker van and even the dumping station accessing our system using an Android and Web application. Overall it will be 360° systems for better waste management with complete automation.

Keywords: Waste Management, Dry Waste, Wet Waste, IoT Devices, Android, Automation.

1. INTRODUCTION:

The astronomical usage of packaged goods, textiles, paper, food, plastics, metals, glass, etc. as a result of rising population and the prevalence of nuclear families is the primary source of the industries' and households' alarming daily waste production rates [1]. As a result, managing this waste becomes an important aspect of our daily lives. There are many effective methods for managing waste in most developed nations, but in some, especially developing nations, people's disregard for maintaining a clean environment, along with other problems like a lack of strict regulations for the use of biodegradable materials, inadequate environmental regulations, and a lack of laws promoting sustainable development, are the germ of waste management's fatal outcomes [2]. The community's rubbish is piled up and the public rubbish bins are overflowing as a result of the increasing amount of waste, which not only make the neighborhood's streets smell unpleasant but also has a negative effect on the environment and public health [3].

Waste is a major problem that requires thoughtful resolution. In order to make garbage processing and recycling easier, we separate it at home. When garbage vehicles visit homes infrequently, it results in the despoliation of residences, as we have seen [4]. Due of this, a lot of citizens empty their stuffed

trash cans in public areas. Consequently, environmental contamination rises. The garbage has several terrible repercussions on the environment and our health[5]. Insects, germs, and flies breed in trash, and these are the same flies that fly about food and lay their eggs. Thus, they raise the danger of foodborne illness, typhoid, gastroenteritis, salmonella, and insects that spread malaria and dengue fever, among other disease., In addition to these flies and insects, other species that benefit from the rubbish include rats and stray canines who transmit sickness and different respiratory illnesses caused by the garbage In addition to harming human health, hazardous contaminants like CO₂, methane, and nitrous oxide also have a negative impact on the ecosystem, creating air pollution and water contamination[6]. Hazardous waste disposal in water, such as electronic garbage and plastics, has an impact on marine life and indirectly on humans. Garbage that is piled up is also a nuisance to the community. Everyone want to travel to new, clean cities. Having trash all over the area and a bad smell deters tourists, which reduces revenue and business chances[7].

Pune is located on the Deccan Plateau in around latitude 18°32"N and longitude 73°51"E, rising to a height of 550-565 m (average height of 1835-1845 ft) above sea level[8]. Pune is the 6th largest computer industry centre in India. Recently, the city has become a significant educational hub, with virtually all of the world's students studying in Pune. Schools in information technology, education, management, and training draw students and professionals from various nations, including India[9]. From 1901 to 2017, the city of Pune's population grew gradually, placing a greater burden on the Pune Municipal Corporation's garbage management system. One of the major sources of waste is the waste collected from households. The household level waste is increasing day by day which consists of Dry, Wet and another mixed types of waste (biodegradable, Electronic) etc. Furthermore, the water content is too high for waste, which requires extra fuel for incineration[10]. Figure 1 shows the waste segregation of the PMC area from the household.

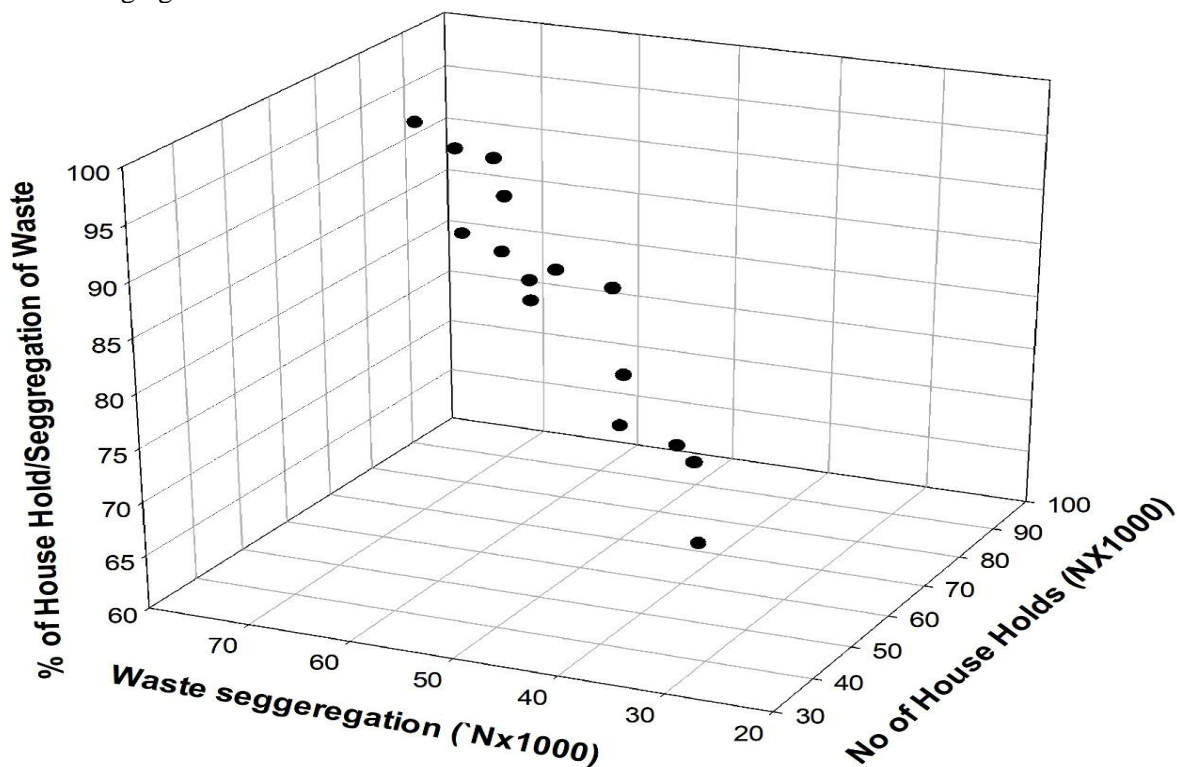


Figure 1: PMC % of waste segregation in households

The above figure 1 shows the amount of household and household waste collected that information is 100% properties-wise waste collection and information on daily waste given to the waste picker is insufficient so the effect on the sounding environment and aesthetic view of the city. Moreover, waste

collected from the outskirts of roads and street swiping is increasing continuously at the ward level.[11]

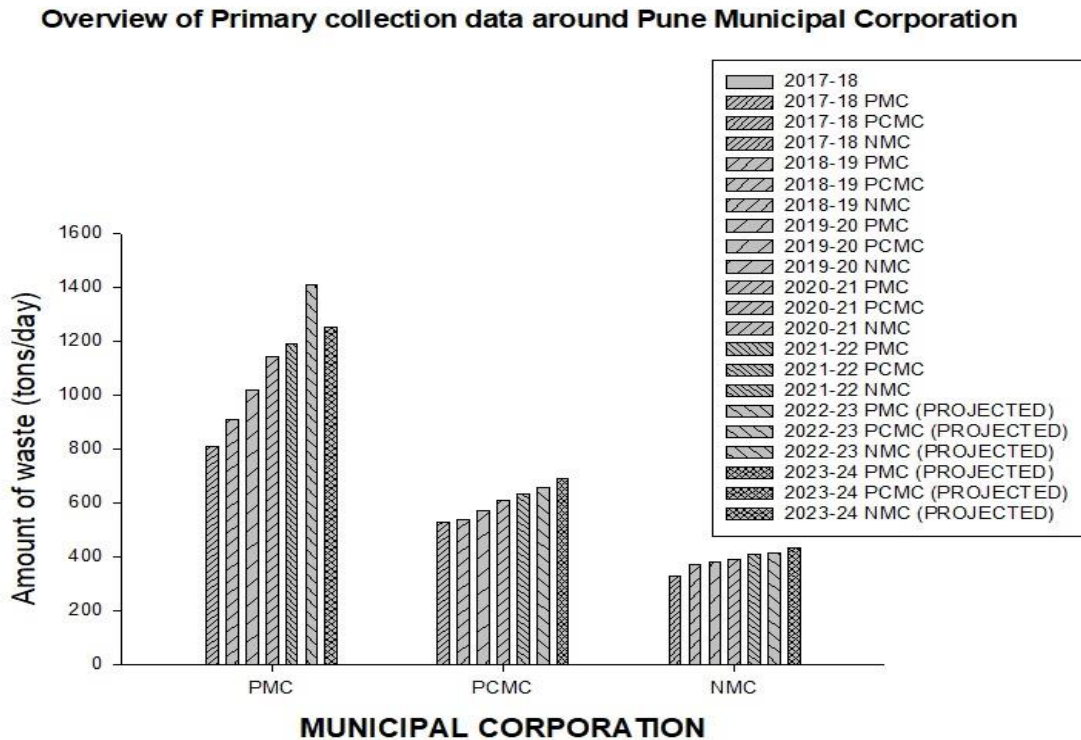


Figure 2: Overview of Primary collection data of PMC around Municipal Corporation)

A study of city of Pune and its current main solid waste collection status by the municipality is depicted in the graph above. When collecting all municipal data take the waste collection data for the past three years and find the statistics for the next three projected years. It shows that waste collection should be continuously scaled up with all previous and projected municipal statistics[12].

The following are a few of the main justifications for the door-level collection of 100% municipal solid garbage. In the collection of primary waste daily, timely waste collection and identifying the source of the waste collection is very important.

1. Waste has been thrown at Chronic Sites daily.
2. Unevenness in waste user fee collection.
3. Daily waste is not given due to the Laziness of citizens.
4. Multi-storage building common collection not done properly.
5. Daily waste collection time and office time are different.
6. Waste is not segregated at the household level
7. Multiple days of waste to be stored in a plastic bag

We chose to create a Smart IoT-based Trash Management System based on Android and Web Apps since the Pune Municipal Corporation's present waste management approach has limits and causes[13]. The uniqueness of our system is that we are creating a separate interface for Users, Waste Pickers and Administrators at the central dumping station which makes it beneficial to get a complete overview of the waste collection management system. The home users as well as industry users will be given a unique RFID card (Radio Frequency Identification Card) through which they will deposit the waste in the allotted dustbin and daily/weekly/monthly monitoring will be done on this by the administrator[14]. Failing to do so we had also made provision to charge fines to the home users and

industrial users which will make some kind of discipline to citizens. Through this system, we are trying to achieve 100% waste management for Pune City.

2. METHODOLOGIES:

The smart waste management application with 100% door-to-door waste picking was designed and developed using IoT with web and Android technologies[15]. Our goal is to give a user-friendly application for household users, waste pickers, drivers and dumping station admins. The application is broadly classified into 2 ways

1. An Android-based mobile application for users for dropping waste in dustbins. The drivers and waste pickers will also use the same Android application for the collection of waste and tracking the route of the ward wise.
2. The web application is majorly for the dumping station admin which will help the Municipal Corporation to manage and administrate the waste picked up as well as to track the user defaulters. Various reports will be generated from the Management Information Services (MIS) perspective like day-wise collection, dry/wet collection etc.

The entire system block design for our smart waste management system is shown in Figure 3.

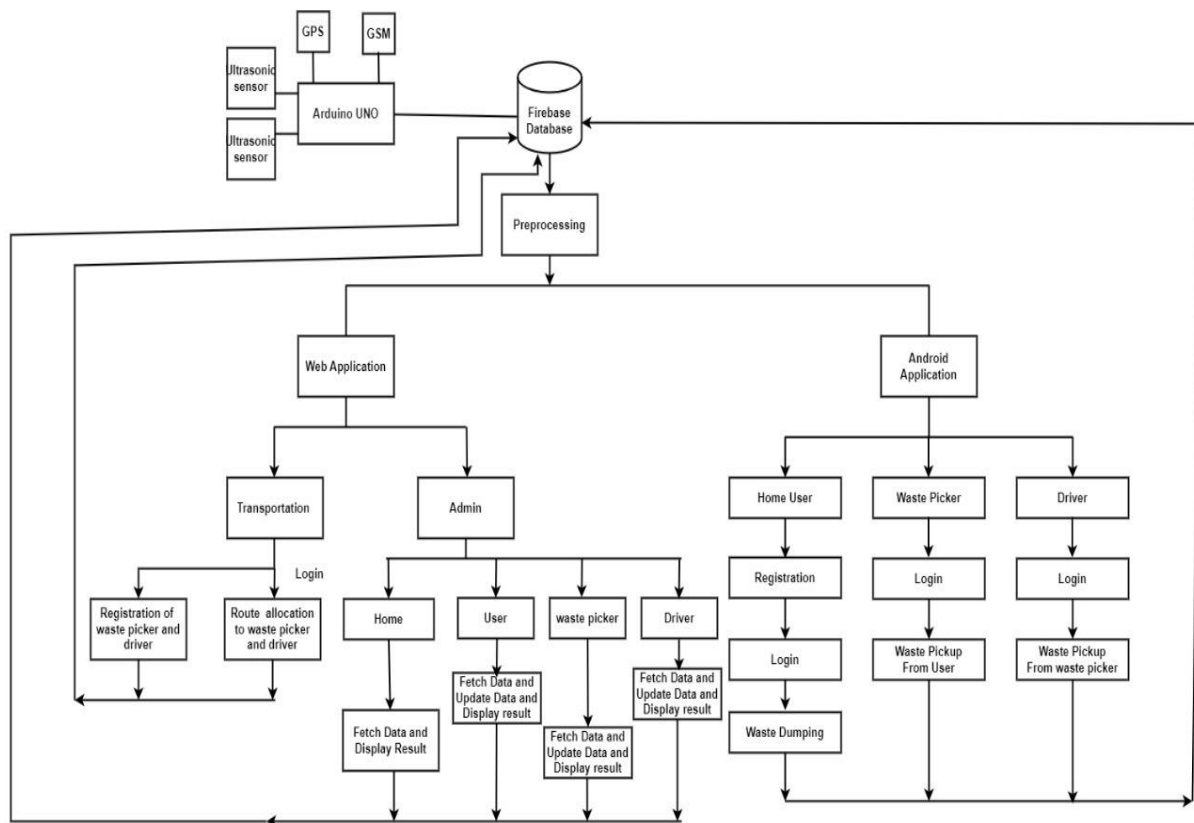


Figure 3: Block Diagram of Smart Waste Management System

2.1 The hardware interface

The IoT kit consists of various sensors like ultrasonic sensors, GSM, and GPS modules along with an Arduino Uno kit for understanding the level of the dustbin placed near the home users[14]. Every home user will be given a unique RFID card after registration in our system. Figure 4 shows the hardware interface kit designed for our system.

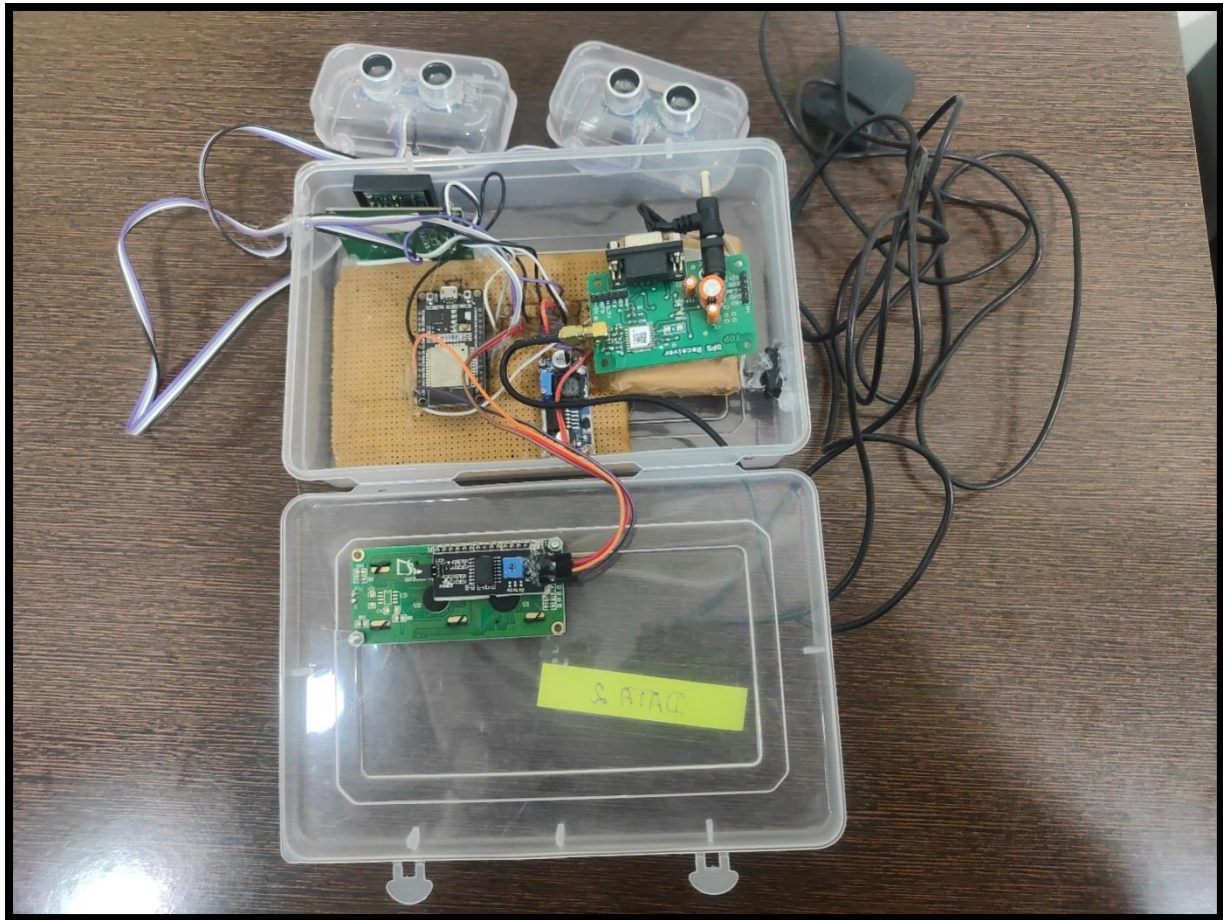


Figure 4: The Smart Waste Management Kit provided to Home Users

Every hardware kit consists of two ultrasonic sensors to identify the garbage level of dustbins. There are two ultrasonic sensors: one detects dry waste, the other moist waste. The kit includes an Arduino Uno ESP microprocessor that was specifically coded in C[14]. The home users will be dumping their waste in respective dustbins. The ultrasonic sensors will be sensing the level of the respective dustbins and with the help of GSM and GPS modules, they will be uploaded the data into our cloud-based database[16]. We used the Firebase database for our application as it has great compatibility with Android applications and it also has the advantage of real-time data upload[17]. Figure 4 shows the hardware kit provided for the home users. The waste pickers who also got a login to an Android app will be visiting the allocated route and they will be provided hardware kit. The waste picker will visit door-to-door in the allocated area and the waste picker will be picking the waste from home users on daily basis based on the level of the dustbin. We had kept an 80% threshold for dustbin level and as mentioned earlier, the firebase database gives real-time data, the moment the dustbins are more than 80% garbage, the alert will be sent to waste pickers to collect the garbage from respective home users.

2.2 Waste pickers Vans

Further part is then carried out by the waste pickers vans. These are our garbage vans which will be sent by the admin based on levels of garbage collected by waste pickers on a particular route. The driver will be getting an alert again with the same android app which we had designed for our smart waste management system. They will be having their login to understand various things like route allocated, level of dustbins etc.

The waste picker vans will collect the dry and wet garbage from a particular route allocated and once their van gets more than the 80% threshold the admin of the system will get an alert in their web

application to understand on which route the waste collection is completed. Accordingly, they can manage the process at the dumping station.

2.3 Web application

The separate web application was designed using HTML, CSS, and JavaScript along with the Firebase database for the entire admin control of our smart waste management[18]. It majorly contains two modules as per the following description

2.3.1 Admin Module

The admin of our web-based application is assigned at the main dumping station of the Municipal Corporation. He is the sole controller of our system. He can get a view of an entire system in one glance as we had provided a dashboard for the admin to manage all operations of our system. The major task which is getting performed by admin is as follows

1. Authentication of all types of users(Home, Driver, Waste Pickers)
2. Fetching data from time to time from real-time firebase database and
3. Generate various reports for analyzing and controlling smart waste management to ensure 100% door-to-door waste pickup.

All the above reports and results will be discussed in section 3 of the results and discussion.

2.3.2 Transportation Module

The web application design also consists of the transportation module which specifically focuses on the waste pickers and drivers.

The major activities which are getting carried out by the transportation modules are as follows:

1. Registration of Waste Pickers and Drivers
2. Route allocation to waste pickers and drivers.

3. RESULTS AND DISCUSSION

We shall describe the system's outcomes in this section. It is a smart waste management system. As our objective is to collect 100% door-to-door waste collection, our system designed and developed achieves it by giving proper notification and defaulters list of users who are not regularly putting their wastes in their respective dustbins.

Figure 5 represents the dashboard of the admin of our system for smart waste management. Once the admin logs in to the system, he/she will be able to visualize the system at once glance with proper pie charts for daily collection of waste based on the waste picker, route-wise and drive-wise. Along with this he/she can monitor the number of active home users, drives and waste pickers on duty daily.

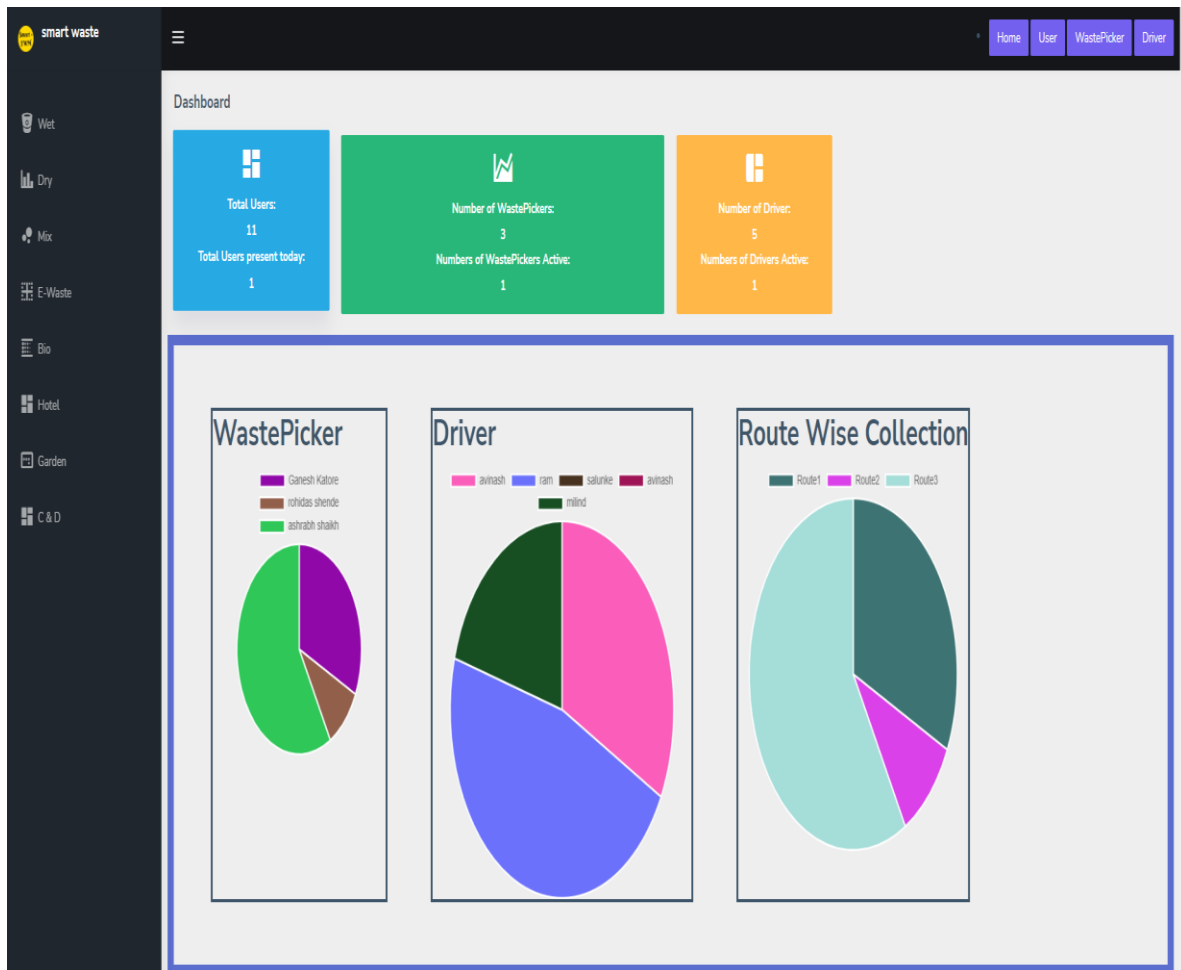


Figure 5: Home Page (Dashboard) of Admin

Figure 6 represents the user page that which admin can visualize. Here the admin can visualize the user's waste level daily. This is a very important report in our system as it gives a glance at whether the user is active or not for dumping his/her waste in the dustbin. The daily report can be seen by the admin for that particular user along with total waste collection, total waste treatment, and total waste disposal done so for every user. This is one of the important pages which help to achieve 100% door-to-door waste management. The alerts will be sent to the users by the admin if he frequently fails to dump the waste in the dustbin. We will be also making provision for users to make some fine in rupees if he fails to deposit the waste in the dustbin.

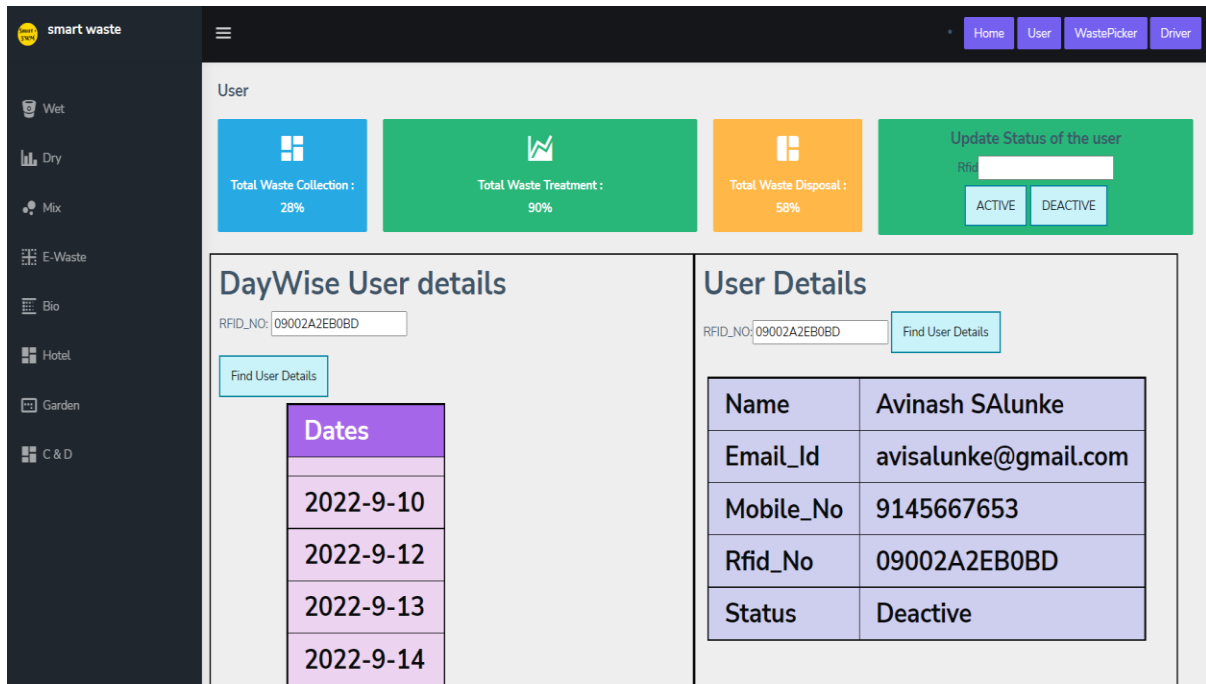


Figure 6: User Page

Our system also gives the facility to export various reports into excel for further management of MIS reports for analysing the data. The different reports which can be exported are as follows:

1. Day-wise waste collection report
2. Route-wise waste collection report
3. User availability report
4. Driver availability report
5. Type of waste collection (Dry/Wet)
6. Waste pickers reports
7. Waste pickers route wise collection report
8. Driver-wise/route-wise waste collection report.

One such sample report exported in excel is shown in figure 7. It shows the active user report generated from the system.

User_No	UserName	Email	Mobileno	Password	Status	Rfid	apartment	city	pincode	route	street
1	Avinash salunke	avi@yahoo.com	9145766435	12345678	Deactive	09002A2EB0BD	noble manchester	narhe	411041	1	navle hospital
2	snehal gorad	snehal@hotmail.com	9145785632	123456789	Deactive	09002D690B46	vyankatesh	katraj	411065	2	sinhgad road
3	komal babar	komal@gmail.com	9456781236	1234567890	Deactive	09002D6A602E	iskon	pune	413256	1	jekkan naka
4	madhuri patil	madhuri@gmail.com	9456321587	123456789	Deactive	09002D72BFE9	pawar house	pune	413702	3	navle bridge
5	snehal salunke	snehal@yahoo.com	9658741236	1234567890	Deactive	09002D91D560	shreyash garden	pune	410141	1	datta nagar road
6	pratima shinde	pratima@gmail.com	9856321475	123456789	Deactive	1D0080A2BD82	ashwini heights	pune	411041	2	nathe road
7	pooja shinde	pooja@gmail.com	9532687412	1234567890	Deactive	1D0080A4D8E1	parthavi imerland	pune	324567	2	swami narayan road
8	vikas jaiswal	vikas@gmail.com	9876541239	1234567890	Deactive	5500CBF24A26	arihant	narhe	411041	2	navle road

Figure 7: User Report exported in excel

Our goal was to achieve 100% door-to-door waste collection using IoT and MIS systems. When we tried and tested this application on two routes in ward 56 in Pune Municipal corporation with 11 users and 2 waster pickers and 2 drivers, it has given promising results and the system was quite well functioning. It has given 100% results and that has encouraged us to take this system to a wider level.

4. CONCLUSION:

incorrect management of household garbage leads to problems with public health and ecological degradation. Hence nowadays many countries are giving a lot of importance to waste management. Indian Government had also launched Swatch Bharat Abhiyan. In order to support the clean city goal, we devised and created an IoT-based web and android based in this paper that aims to offer a workable solution for effectively managing garbage. The suggested approach is user-friendly, and when we test the prototype model in one wards of the Pune Municipal Corporation, the results were quite encouraging and we were able to achieve 100% door-to-door rubbish collection..The suggested approach is user-friendly, and when we test the prototype model in one wards of the Pune Municipal Corporation, the results were quite encouraging and we were able to achieve 100% door-to-door rubbish collection.The suggested solution will assist in resolving all significant waste-related problems and preserving the environment. In our future plans, we hope to advance this system in order to handle industrial trash, bio-waste, and electronic garbage in an intelligent manner.

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