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QR Code Enabled Domestic Waste Segregation Tracking

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Abstract

Bruhat Bengaluru Mahanagara Palike (BBMP) is spread around 713 Sq. Km area with total population of 1.3 Crore, generates around 4,500 Metric tons per day of domestic solid waste at an average of 309 grams in city and from slum is 300 grams per day. In metropolitan areas, a huge quantity of household solid waste is generated, which containsa variety of materials such as organic wastes, paper, plastic, metal, glass, and so on. To promote this process, the government developed the concept of waste segregation encouraging people to dispose trash separately for efficient waste management. Because of no proper segregation at source, currently 15% of garbage is treated and remainingis being dumped into landfills. Considering above problem, the proposed system will have track on whether collecteddomestic waste is segregated or not. To have track on waste segregation we have designed QR code tags and smartphone application. QR tags contain information of electric meter number, using smartphone application waste collector can scan the QR tags to fetch the electric meter number, in the designed application dashboard it contains fields like kind of waste, segregation status and so on. According to the segregation status waste collector should upload photo of the waste to have proper tracking. If waste is not segregated processing become tedious and waste will be dumped into landfills. Pollution of air, water and soil can be considerably reduced when waste is separated and treated.

Keywords
Electric meter number, Landfills, Metropolitan areas, QR tags, Waste Segregation

1. Introduction
India has second highest population in the world, Contributing 17.6% of world's population. Globally,Indians create over 2.01 billion tons of solid trash each year, according to World Bank estimates. 377 million people reside in 7935 cities and towns, producing 62 million tons of trash every year. Only 43 million tons of trash are accumulated, 11.9 million tons are handled, and 31 million tons are dumped in landfills. Trash disposal was not a serious issue for decades because the population was low and there was plenty of available space for dumpsites. However, now it has become a major issue everywhere.

With an estimated population of 8.4 million people, Bangalore generates roughly 4,500 metric tons of municipal solid trash every day at an average of 0.5 kilograms per day. Only around 60% of garbage is collected, and only about 15% of waste is treated before being buried in landfills. While recycling in Bangalore's urban and rural areas has yet to meet final goals, landfills, trash burning, and illegal dumping are all too commonly found everywhere.for Current year BBMP total budget outlay is put at Rs 10,480.9 crore, a substantial increase from last year's total ofRs 9,286 crore. Two-thirds of the budget, Rs 6,911.5 crore, has been set aside for the Public Works Department (PWD).

The collected solid waste from houses is brought to a common point, i.e., secondary locations from where the waste is transferred to landfill sites/treatment through tipper lorries and compactors. A typical scheme of how the collection and transportation are being practiced in most of the wards. in many wards it indicated that no norms/guidelines had been followed in setting up waste segregation practices adopted in this ward. There is a lack of awareness among people that leads to confusion. The waste collectors (pourakarmikas) lack training in proper segregation practices andits importance. Incomplete segregation is the predominant practice currently, and steps to realize a higher level of compliance and efficiency need to be affected. Figure 1 below shows the division total waste in 2021 and Figure 2 shows the anticipated (forecasted waste in the next 20 years)

Motivation of research is to 1. Reduce the landfills space 2. Segregating waste at home as it is easy 3. To overcome inefficient municipal solid waste management 4. Waste disposal effects on BBMP worker's health.

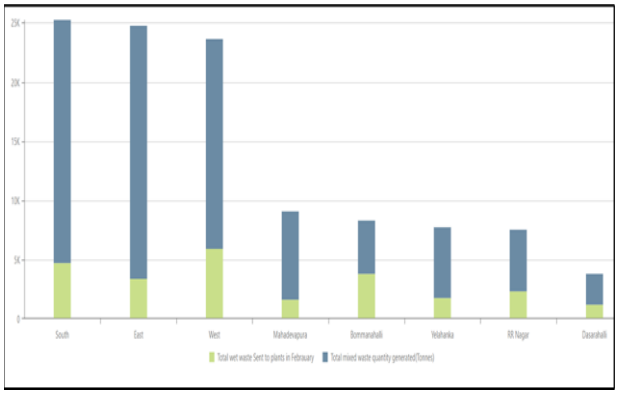

Figure 1. Division wise Total waste (Wet & Mixed) generation status for the year 2021

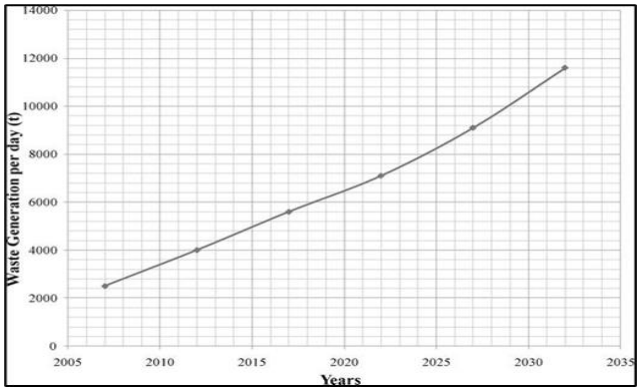

Figure 2. Waste expected during the next 20 years

Waste Segregation

The solid waste generation mainly consists of biodegradable (cooked food/leftover food, vegetable/fruit peels, egg shell, rotten eggs, chicken/fish bones, tea bags/coffee grinds, coconut shells and garden waste) and non-biodegradable(plastic covers, bottles, boxes, cups, toffee wrappers, soap or chocolate wrapper and paper waste tins/cans rubber/thermocol. waste materials are primarily generated as a result of various societal activities. Improper solid waste disposal causes environment pollution.

The current study focuses at how to enhance waste processing and minimize the quantity of garbage that needs to be carried and disposed in landfills, with the goal of reducing health consequences for pourakarmikas or BBMP workers

1.1 Problem Statement

In metropolitan cities illegal landfills are increasing due to no proper waste segregation at source. Government already introduced the concept of waste segregation. But civilians are not segregating the waste at source, becauseof no proper tracking system on waste segregation. To have track on waste segregation we have designed the QRtags on which QR Code is printed which contains the information of electric meter number, which can be fetchedby scanning QR code by the developed smartphone application.

1.2 Objectives

1) To survey the public on waste segregation
2) To track the domestic waste segregation
3) To minimize the waste and ensure reduction in landfill space
4) To enable cleaner and more efficient waste segregation processing
5) To provide suitable suggestion to individuals regarding the waste segregation in their daily waste disposal

2. Literature Review

Hossain and Islam, (2022) focuses on current plastic waste generation and Plastic Waste Management in India. In this study, NVivo, VOS viewer, and Microsoft Excel are employed to analyze the articles and information sources' quantitative data This study helps to identify implementable strategies for policymakersand research opportunities for future researchers in holistic PW management and recycling in India. Particular attention is given to integrating informal recyclers into formal collection and recycling channels and implementing unique recycling technology for multiplayer plastic polymers. In terms of limitations of the study, this study concentrates on only plastic waste management in coastlines. Scholar's Comments about the Research work are like Particular attention should be given to integrating informal recyclers into formal collection and recycling channels.

Naveen (2021) highlights on a comprehensive review of Bangalore's waste management has been provided to elaborate on the current status, the information was collected from Bruhat Bangalore Mahanagara Palike (BBMP) personnel with different responsibilities within the system and the main findings of this paper It identifies municipal solid waste management (MSWM) problems and limitations that hamper improvement in the current waste management practices. Limitation of the work the study concentrates on only waste management in Bangalore urbancities. Bangalore needs a fool proof system to manage the solid waste generated. The system should have a strict monitoring mechanism for the implementation of waste management rules.

Widaningsih and Suheri (2021) explores admin only needs to scan QR code label attached on the waste bin storedabove weighing device using a smartphone camera. This way input data process can be faster and with the use of QRcode, more data can be stored. The waterfall model is used which consists of several sequential stages like design, analysis, implementation and deployment. Description of the system will be made and functional requirements of thesystem of the system are model the result of this research is design of waste management using QR code. There are two result f main design in form of QR code and interface design. Weakness of the system including the need for papers for data storage media, data is easily lost, and the need of time to input data so its inefficient.

Abdullah and Rana (2021) Waste management is a risky business that must be made more sustainable. It has to be eco-friendly, commercially successful. Arduino is now a widely available computer-based structure and development, business, and customer communications platform for designing and manufacturing computational gadgets and smart products that recognize or govern things in today's world in the presence of light, the solar panel connected to the system generates electricity, which is then stored in the volts battery via a charge controller. With a decreased demand for moist and dry trash, the structure can isolate each type of garbage in turn dueto a lack of effective isolation measures, a large amount of untreated trash is dumped in landfills According to a reportreleased by the World Bank, around 1.3 billion tons of municipal garbage are created each year

Kihila and Wernsted (2021) Waste segregation can reduce the amount of waste that has to be handled, improving collection and disposal efficiency. The purpose of the choice experiment was to learn about people's perceptions on what might cause segregation to change. Finally, waste streams were measured in 80 (randomly selected) homes in order to better understand waste generation, composition, and recycling and recovery potential These findings demonstrate that the composition of household garbage lends itself to significant resource recovery, such as re-use, recycling, and regeneration It is critical to include community perspectives on what they believe should be done to improve trash segregation. It appears that the desire to prevent pollution triumphs over all other considerations. This is in line with findings from research conducted in Malaysia and Ethiopia.

Pardini, at al. (2020) emphasizes on a system follows an IoT-based approach where the discarded waste from the smart bin is continuously monitored by sensors that inform the filling level of each compartment, in real-time. The society model of the 21st century has been increasingly influenced by cities in their context. According to the United Nations data, by 2050, approximately 70%of the population will live in urban centers, and this rapid growth of people living in cities has been of great concern,since towns do not always grow in a sustainable way Taking into account the creation of a real prototype of the smartcontainer and the implementation of a new waste management mobile application and corresponding Web version, and based on the case study experiments, it was concluded that the proposed system can efficiently improve the waypeople deal with their garbage and optimize economic and material resources.

Hull (2019) explores the use of a drive-up window near areas dealing with container preparation, delivery, pickup,and disposal is included Database of waste definitions-transporter, disposal, and waste stream storage Lot, printing labels, and a database of portable bar codes The timeframe for system design, material procurement, assembly, proof-of-concept, troubleshooting Scannable barcodes made all stages of container preparation, delivery, pickup, and disposal must be physically close to the operation There is no proof that this type of activity adds value. With the potential for many risks to have an influence

Jayson and Hiremath (2018) state that SmartBin, a bin that is able to segregate waste at source with no human intervention and can automatically alert the waste collection Centre when the bin is full The entire system is programmed using the Arduino IDE, Arduino Mega 2560, Servomotor MG995, IR Proximity sensor and GSM Module SIM 900AThis module can be considered with the Government of India's Swachh Bharat scheme to reuse and recycle resources and enables scientific waste management methods. self-charging technology when the battery of the SmartBin is low on power can be limitation of this paper. Scholar's Comments about the Research work Manualwaste segregation is very expensive, time consuming and inefficient.

Kumar, et al. (2017) highlight on the problems, limitations, and possibilities involved with enhancing waste management in India in the present study authors use Applied research and historical data. Value extraction from trash can be materials, energy, or nutrients, and this can offer a life for many people, according to theauthors of the current study. Only by investing in SWM will we be able to make the transformation from waste to resources. The study concentrates on only solid waste management and Comparative analysis based on historical datanot based on present findings Demotivation and a lack of environmental knowledge have stifled innovation and the adoption of innovative technology that may improve garbage management in India. In India, people's perceptions around waste are also a key impediment to developing SWM.

3. Methods

As indicated below, the required data was collected using well-structured questionaries, and the data was analyzed using the following techniques.

1) **Correlation:** Is a statistical measure, the degree to which two variables are linearly related. The computed correlation matrix for variables or questions mentioned above and the obtained correlation values are as below.

2) **Logistic Regression:** Logistic regression is one of the most popular Machine Learning algorithms, which comes under the Supervised Learning technique. It is used for predicting the categorical dependent variableusing a given set of independent variables. Logistic regression predicts the output of a categorical dependentvariable. Therefore, the outcome must be a categorical or discrete value. It can be either Yes or No, 0 or 1,

True or False, etc., instead of giving the exact value as 0 and 1, it gives the probabilistic values which liesbetween 0 and 1.

4. Data Collection

The current study aims to track domestic waste segregation in Bangalore Urban area. The sample size is five times larger than the number of variables. The sample of the current study is 194 individuals. Well-structured questionnairehas been designed for data collection and responses were tabulated into excel and further analysis was carried out and illustration of our field effort are as in Figure 3 and 4

i. Are you doing waste segregation at home?
ii. Do you think segregation of waste is useful?
iii. In your locality are the BBMP garbage collector collecting the waste properly?
iv. Has the BBMP garbage collector informed you to separate wet waste and dry waste?
v. Have you been provided with separate dustbins for wet and dry waste collection?
vi. Have they imposed any fines in your locality for not segregating the waste properly?
vii. If BBMP makes mandatory to buy QR code printed waste collection bags or dustbins in order to track segregation, will you buy?
viii. How many days a week the garbage collector comes to your locality for dry waste collection?
ix. Is the garbage collector collecting wet waste in your locality on regular basis?

Figure 3. Showing waste collected being dumped in the BBMP ward

Figure 4. Mixed waste taken to processing

5. Results and Discussion

According to our survey we found waste which is collected by BBMP is not completely segregated according to the rules and proper waste treatment is also not going on in many wards. Waste which are collected without any proper segregation are compressed and dumped in the landfills which can be dangerous for the environment as the segregationis not done properly. Our project mainly concentrates on tracking the waste which is not segregated by the people mainly households.

So, we propose this idea "*QR Code Enabled Domestic Waste Segregation Tracking*". Through which we can find the homes which are not segregating the waste and impose the fine on them so that in future same mistakes in not repeated by them. Our project can make waste segregation process from household 100% success. Once waste is segregated according to wet waste and dry waste treatment of waste will become very easy task.

5.1 Numerical Results

5.1.1. Correlation matrix: The computed correlation matrix for variables or questions mentioned above and the obtained correlation values are as below in **Table 1**

Table 1. Correlation Matrix

	Are_you	Do_you	Collector	Collector_inform	Sep_bins	Fine_local	Days_Garbage	Wet_Waste
Are_you	1							
Do_you	0.118624327	1						
Collector	0.365066287	-0.00509	1					
Collector_inform	0.260812814	-0.00509	0.334526473	1				
Sep_bins	0.192297594	-0.03541	0.383128976	0.43274648	1			
Fine_local	0.167968482	0.00406	0.206360463	0.329013435	0.447773475	1		
Days_Garbage	0.092439681	-0.0231	0.33715695	0.359711588	0.260380984	0.296199089	1	
Wet_Waste	0.219367521	0.049899	0.526323289	0.239184037	0.271585501	0.288869226	0.288560863	1

The collected data is further exported into excel sheet and correlation among the variables is computed. The possible values for correlation are between -1 and +1. The values of correlation are not too high. If the correlation coefficient is greater than zero, the relationship is positive. If the value is less than zero, it is a negative relationship. If two variables are positively correlated that means if one variable increases the other variable also increases or if one variable decreases the value of the other variable also decreases. The above matrix highlights three strong correlations. All the other remaining variables are not strongly dependent on one another.

5.1.2. Logistic Regression

Logistic regression is one of the most popular Machine Learning algorithms, which comes under the Supervised Learning technique. It is used for predicting the categorical dependent variable using a given set of independent variables. Logistic regression predicts the output of a categorical dependent variable. Therefore, the outcome must bea categorical or discrete value. It can be either Yes or No, 0 or 1, True or False, etc., instead of giving the exact valueas 0 and 1, it gives the probabilistic values which lies between 0 and 1. Jupyter notebook is made use to run the pythoncode to compute the logistic regression for the collected data.

Following steps are followed in Jupyter notebook to get the desired output as **in Figure 5, Figure 6** and **Figure 7:** -

STEP 1: - Few libraries like numPy, pandas, matplotlib and stats models are imported.

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline

# You can safely ignore the warning:
#  Please use the pandas.tseries module instead. from pandas.core import datetools
import statsmodels.api as sm
QR_code = pd.read_csv('QR_Code_Logistic_Regression.csv')
```

```
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\compat\pandas.py:56: FutureWarning: The pandas.core.datetools module is
deprecated and will be removed in a future version. Please use the pandas.tseries module instead.
  from pandas.core import datetools
```

Figure 5. Python code that imports all the required libraries

STEP 2: - After importing the required libraries, excel generated from the questionnaire is converted into comma separated value(csv) file. This file is imported into Jupyter as shown in **Figure 5**. The imported csv file is displayedin Figure 4. The screenshot shows a snippet of 9 rows* 13 columns out of 194 rows* 13 columns.

QR_code

	Name	Age	Local	Prof	Are_you	Do_you	Collector	Collector_inform	Sep_bins	Fine_local	Mandatory_QR	Days_Garbage	\
0	abhishek	23	Bangalore	1	1	1	1	1	1	0	1	2	
1	Gagan	24	Kalyan nagar	1	0	1	0	0	0	0	1	3	
2	Nalinakshi H S	24	Yelahanka	1	1	1	1	1	1	1	1	3	
3	Girish K S	22	Peenya	1	1	1	1	1	0	0	1	3	
4	Anusha MG	22	Rajajinagar	1	0	1	1	1	0	0	1	2	
5	Shobha	49	Yelahanka	2	1	1	1	1	1	0	1	3	
6	Rathna	55	Yelahanka	3	1	1	1	1	1	0	1	2	
7	Sanjay K S	22	Gandhi Nagar	1	1	1	1	1	1	1	1	2	
8	abhishek	23	Bangalore	1	1	1	1	1	1	1	1	2	
9	Sanjay K S	22	Gandhi Nagar	1	1	1	1	1	1	1	1	2	

Figure 6. The output for the code

STEP 3: - Defining of dependent and independent variables as X train and Y train, X train consist of dependent variables and Y train consist of all the independent variables (Mandatory_QR). The model is built and data is fitted, to obtain logistic regression.

```
# defining the dependent and independent variables
Xtrain = QR_code[['Age', 'Prof', 'Are_you', 'Do_you', 'Collector',
       'Collector_inform', 'Sep_bins', 'Fine_local',
       'Days_Garbage', 'Wet_Waste']]
ytrain = QR_code[['Mandatory_QR']]

# building the model and fitting the data
log_reg = sm.Logit(ytrain, Xtrain).fit()
```

```
Optimization terminated successfully.
         Current function value: 0.469459
         Iterations 6
```

Figure 7. Dependent and Independent variable

X and Y

STEP 4: - Summary table is obtained by print (log_reg. summary) and shown in **Figure 8**

```
# printing the summary table
print(log_reg.summary())
```

```
                           Logit Regression Results
==============================================================================
Dep. Variable:           Mandatory_QR   No. Observations:                  194
Model:                          Logit   Df Residuals:                      184
Method:                           MLE   Df Model:                            9
Date:                Fri, 22 Apr 2022   Pseudo R-squ.:                0.06450
Time:                        15:49:29   Log-Likelihood:                -91.075
converged:                       True   LL-Null:                       -97.355
                                        LLR p-value:                    0.1836
==============================================================================
                   coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
Age              0.0445      0.024      1.862      0.063      -0.002       0.091
Prof            -0.4548      0.263     -1.728      0.084      -0.971       0.061
Are_you          0.2965      0.548      0.541      0.588      -0.777       1.370
Do_you           1.0095      0.584      1.729      0.084      -0.135       2.154
Collector       -0.8040      0.605     -1.329      0.184      -1.989       0.381
Collector_inform 0.0246      0.514      0.048      0.962      -0.984       1.033
Sep_bins        -0.1404      0.459     -0.306      0.760      -1.040       0.759
Fine_local       0.2151      0.442      0.486      0.627      -0.652       1.082
Days_Garbage     0.0458      0.187      0.244      0.807      -0.322       0.413
Wet_Waste        0.4099      0.532      0.770      0.441      -0.633       1.453
==============================================================================
```

Figure 8. Logistic regression result

The dependent variable taken is If BBMP makes mandatory to buy QR code printed waste collection bags or dustbinsin order to track segregation, will you buy, the number of observations indicates the number of responses obtained from the survey. P>|z| indicates that if it any of the parameter is within 0.05 it affects the dependent variable.

5.2 Proposed Improvements

- The study can also be carried out at various other geographical areas
- The collected sample size for the project undertaken is can be a larger sample size
- It is suggested to use Convolutional Neural Network (CNN) to achieve segregation. This can be designed to reduce human intervention in segregating waste
- Image processing capability can be used to determine the kind of waste using machine learning.
- It is suggested to introduce smart bin concept**.**
- The current application require internet, in future it can be implemented in offline mode.

6. Conclusion

Door to Door step of collecting waste from people by sending BBMP vehicles separate for both dry and wet waste has not been completely effective. Arguments between BBMP workers and the residents have been reported over gathering of unsegregated waste. Employees have been facing too much difficulty to separate the waste later once allthe waste has been collected. And because of the mixed waste it is also becoming difficult to recycle reuse and causingproblems while land filing too. This is leading to pilling up of wastes in the landfills and leading to more and more illegal dumpsites in the city consuming more space to dump the waste.

Mixed waste makes it difficult to worker, as it requires much manual or mechanical sorting this puts workers health in danger especially hazardous waste can cause long term health problems as well as time taking and the waste that are been dumped in the compressor are not completely segregated. Due to unsegregated waste that has been collected

the process of compressing becomes more difficult and segregating them will be time taking and leading to pile up of waste in the wards.

The waste that are collected by BBMP are then compressed and taken to landfills and dumpsites far away from the residential area but due to the improper waste segregation and recycling process the landfills are getting piled up leading to giving rise of illegal dumpsites and covering more space and time to waste management.
Communities surrounding landfills are facing issues with their drinking water due to leaking landfills that is caused because of improper segregation wet waste and dry waste again as well as workers health and hygiene are affected even more.

The detail analysis has been done with the help of collected responses through well-structured questionnaires to and from that we came to know that in most of the areas waste segregation is not happening and that increases the amountof waste that reaches to the landfill. to identify these, we have developed a smart phone application and also designeda QR code tags to scan the dustbins.

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Biographies

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Balaji N, Brunda A and Gagan M B are final year MBA students at the Ramaiah University of Applied Sciences and performed this Research Study under the guidance of Dr. Uday K Jagannathan.