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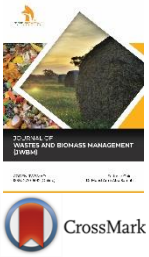

RESEARCH ARTICLE

PEOPLE'S PARTICIPATION AND PERCEPTIONS IN THE SOLID WASTE MANAGEMENT OF MANGALORE CITY CORPORATION, KARNATAKA, INDIA

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ABSTRACT

The alarming increase in municipal solid waste (MSW) generation and its complex characteristics pose a significant threat to people and the environment worldwide. The success of solid waste management (SWM) depends on the involvement and active participation of all stakeholders, and in particular, the people in households play a vital role. The primary objective of this paper is to assess awareness, perception, and participation and suggest how an effective SWM can be achieved. Hence, the article aims to present the participation and perceptions of people with regard to the current Municipal Solid Waste Management System (MSWMS) in Mangalore City Corporation, Karnataka State, India. The feedback from 410 people from various households was collected based on gender, age, income, education status, etc. The Statistical Package for Social Sciences (SPSS) was used to analyze these datasets. The study shows that there is variation in the participation of people in all wards, and in some wards it is not satisfactory. It identifies areas where participation is lacking and highlights a potential gap between public perception and the actual state of waste management. The study suggests the need for administrative improvements and strategies based on public feedback to enhance the solid waste management system.

KEYWORDS

Solid Waste Management, Awareness, Public Perception and Participation.

1. INTRODUCTION

Municipal Solid Waste (MSW) resulting from diverse human activities is an inevitable part of the social environment. As the human race enters a modern lifestyle, the threat of rapid growth and waste generated from a variety of activities is increasing day by day. This situation is a warning for the public health, environment, and economies of developing countries (Xiangru et al., 2019; Kumar et al., 2017). Municipal Solid Waste Management (MSWM) becomes even more challenging for cities with high population densities. Since India is a developing country with diverse activities related to industrial developments, rapid urbanization, multiple cultures, religious rituals, and traditions, SWM has become even more difficult to address. Environmental pollution, health issues, and unpleasant aesthetics are some of the prominent effects of a unscientific SWM system (Chand Malav et al., 2020). Based on the composition of the MSW, it can have a serious impact on air and soil pollution. Table 1 presents the list of pollutants and their impact on air, soil, and water resources. Altogether, MSWM involves social, political, environmental, and economic aspects of the country (Heidari et al., 2019).

We can find various theoretical interpretations of MSW in the open literature. As stated by Vergara et al., "MSW is one such waste that comprises all solid and semi-solid materials generated from residential and public localities, excluding hazardous and wastewater in it" (Vegara and Tchoglous, 2012). Accordingly, McDougall F. et al. said MSW are such materials that have no value to the present holder (McDougall et al., 2001). It is also viewed as factual evidence of civilizations by anthropologists while ecologists believe that no materials are called waste in nature (Rathje and Murphy, 1992). It is also referred to as the right thing at the wrong place by an industrialist (Desrochers et al., 2002). Hence, based on the profession and how one looks at the MSW, it can be defined in various phrases.

Table 1: Environmental impact summary on account of various waste technologies (Giusti, 2009).

Domain	Pollutants origin from respective waste technologies			
	Composting	Incineration	Dumping/ Landfills	Recycling
Air	Odour, GHG emissions	SO_2, NO_2, HCL CO, CO_2, GHG, PAHs, VOCs	CO_2, CH_4, odour, noise, GHGs, VOCs	GHGs (minor)
Soil	Negligible impact	Fly ash and slag	Heavy Metals, Organic pollutants	Leftover landfilling
Water	Leachate	Uncontrolled emissions	Leachate, heavy metals	Processing wastewater

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Managing solid waste in developing countries like India becomes a challenge due to its continuously changing compositions, limited policy frameworks, and increasing handling and treatment costs. Before planning any flow scheme for a waste organization, solid waste management begins with quantity estimation. Some of the factors that have a direct impact on waste generation are: population density, the standard of living, environmental conditions, seasons, types of activities, etc. Based on the cities and locations, the waste generation rate across India falls within the range of 0.17 to 0.62 kg per capita per day. The waste generation rate according to the population in India is given in Table 2 (Kumar et al., 2009).

Table 2: Waste generation rate of Indian cities (Kumar et al., 2002).

Population	Waste generation rate (kg per capita per day)
Cities with population <0.1 million (8 cities)	0.17 - 0.54
Cities with population 0.1 - 0.5 million (11 cities)	0.22 - 0.59
Cities with population 1 -2 million (16 cities)	0.19 - 0.53
Cities with population >2 million (13 cities)	0.22 - 0.62

Table 3: Representative composition of MSWs in India cities (Arceiyala and Asolekar, 2012).

Sl No.	Components	Composition (% by weight)
1.	Food and kitchen waste	40 - 65
2.	Paper	1 - 10
3.	Plastic and rubber	1 - 5
4.	Metals	0.2 - 2.5
5.	Glass and ceramics	0.5 - 3.5
6.	Textiles	1.5
7.	Miscellaneous combustible	1 - 8
8.	Miscellaneous incombustible	-
9.	Inert	20 - 50

The composition of the MSW is a prime factor that determines the treatment technique (Chand Malay et al., 2020). This means that if the solid waste is naturally biodegradable, it can be composted, whereas if it is non-biodegradable, then a respective treatment like incineration, chemical treatment, reuse, etc., or a sanitary landfill can be chosen. As discussed earlier, these compositions or characteristics of MSW mainly depend on standard of living, climatic and topographical conditions, rituals, literacy rate, etc. (Jin et al., 2006). This solid waste characteristic becomes even more critical with the diverse cultural, ritual, and rapid urbanization in countries like India (Gupta et al., 1998). Due to the sudden shift towards the electronic world, the e-waste volume has increased in a rapid phase (Chand Malay et al., 2020). Table 3 represents the composition of MSW as observed by (Arceivala and Asolekar, 2012). As reported, the highest percentage of waste composition was wet waste (food and kitchen), at nearly 50%, followed by inert waste and other categories. The waste percentage is classified based on calorific values and moisture content with respect to population a finding from the Central Pollution Control Board-National Environmental Engineering Research Institute (CPCB NEERI) is presented in Table 4. Here, the calorific value describes the amount of heat produced when a material is completely combusted for a specific quantity, and the percentage of water content trapped within the material is represented as moisture content. As reported by Strate et al., the higher the calorific value, the waste can easily be treated with waste-to-energy treatment techniques (Istrate et al., 2020). It is also observed from Table 4 that 50% of MSW in India is dry waste. The informal sector in India collects nearly 40-50% of recyclable waste, which is later sent to recycling units through other means.

Since ancient times, mankind has effectively managed solid waste, but in the modern era due to its complexity and varying characteristics, it has become a serious issue to be addressed. The composition of waste is changing every day since the world is facing advancements in technology and civilization. As reported by Perkins et al., managing solid waste has become a serious challenge, especially with the increase in e-waste composition (Devin et al., 2014). The world has become so approachable that products can be manufactured in one country and discarded in another. This unplanned additional burden over MSW can be witnessed in the inconsistence among regulations and policies for waste management and disposal (Hoornweg and Bhada Tata, 2012). The main aim of any SWM system will be to reduce the environmental pollution caused by man-made materials. But this can only be achieved if the system has sustainable funding, affordable and efficient technologies, and involved participation from the public. If users are ready to pay for waste management, the Private Sector Participation (PSP) will be effectively implemented with a direct impact on the integral system of SWM (Seth et al., 2014). As rightly pointed out by Tai et al. 2011, Vergara et al. 2012, EPA, 2006 the management of solid waste begins from the generation point itself, i.e., majorly individual dwellings (Tai et al.,2011; Vergara and Tchobanoglous, 2012: EPA. 2000/2006).

Table 4: Calorific values and moisture content of MSW in cities of India

Cities with population range	Net calorific values (kcal/kg)			Moisture (%)		
Cities with population of 1 - 5 lakh	1,591	3,766	2,162	24	63	50
Cities with population of 5 - 10 lakh	1,591	2,391	1,481	17	64	48
Cities with population of 10 - 20 lakh	1,520	2,762	1,411	25	65	41
Cities with population of above 20 lakh	1,834	2,632	1,7 72	21	63	47
Source: CPCB-NEERI (2006)						

The opinion and perception of waste management from the users play a significant role in SWM (Maddox et al., 2011). The public can or has to be involved in the decision-making, recycling, and segregation of waste at the generation stage. If there is an inefficient SWM system maintained by an Urban Local Bodies (ULB), it is common to witness illegal open dumping, burning in drains, or barren land. The most extensive part of any successful SWM is played by the public. The prominent rules, policies, schemes, and financial plans for SWM in India are presented in Table 5.According to Merton, the ability to observe, listen, or become aware of something is referred to as perception (Merton, 1968). Similarly, if an individual is involved in any activity, it is termed participation. If the public is not involved at the generation stage, it becomes a difficult task to segregate the waste before one can treat it (Junquera et al., 2001). The individual who illegally dumps the waste across the road or on barren land assumes that it will be picked up by the local municipality. This mind-set of the public leads to an unscientific and inefficient SWM system in India. As observed by David, the cities where the public is involved from the planning stage itself noticed higher rates of participation in product recycling (Folz, 1991). Studies have also revealed that about 91% of MSW collected finds its last point of disposal at either open yards or scientific dumps (Position Paper on the Solid Waste Management Sector in India, 2009).

Table 5: Important Rules, Policies and Financial Schemes of SWM in India (Municipal Solid Wastes Management Manual, 2016)	
Year	**Rules, Policies, Schemes, Financial Plans**
1989	The Hazardous Waste Rules
1994- 1995	MSWM Strategy paper by NEERI J. S. Bajaj committee (Urban Solid Waste Management)
1998	Bio-medical Waste Rules Supreme Court appointed Burman Committee
2000	MSW Rules (management and handling) CPHEEO Manual on MSW
2005	Report on Technology Advisory group on MSW
2006	Strategy and action plan for use of Compost in Cities
2007	11th Five Year Plan (Rs. 2,210.00Cr for MSWM)
2008	National Urban Sanitation Policy Hazardous Waste Management Handling Trans boundary movement Rules Service Level Bench Mark (SLBs)
2011	Plastic Waste Rules E-Waste Rules Draft Bio-medical Waste Rules
2014	Swatch Bharath Mission
2016	Waste Management Rules Construction and Demolition Waste Management Rules

The current study showcases the existing MSWM of Mangalore City with a supporting questionnaire to understand people's perceptions and participation in the SWM system. The main objective of the study was to view the existing SSWM system from the public's point of view and come up with a feasible solution to upgrade the system. Several respondents have provided their input to improve the MSWM practice in Mangalore City. The article to close to reality because the present prevailing SWM system is also presented along with the questionnaire that represents the stakeholder's view of it. A scientific approach has been followed to understand the public's opinion with statistical analysis of the selected sample representing the real world system. This study is highlighting the importance of people's participation and plans some awareness programs to educate the public, community, and all stakeholders for a better system. The article is structured as follows: The first section introduces MSW, public perception, waste generation, rules, and policies in India. The second section describes the features of the study area, followed by a third section explaining the existing condition of SWM in Mangalore City. The fourth section explains the methodology adopted for this study. A detailed discussion of results and findings is presented in the fifth section, and the discussion is concluded with a recommendation in the sixth section.

2. Study Area

Mangalore City is one of the major cities of Karnataka State (Southern India), located in Dakshina Kannada District as the district headquarters. Being the second largest city of the state, it is situated between the Arabic Sea towards its west and the Western Ghats towards its east (12°147'N latitude and 74° 50' E longitude). With an airport, harbour, roadways, and railways, the city is well-connected within the country and even across the globe. The city area has been rapidly converted into a developed area over the past 20 years (Sanjith, et al., 2018). The city is divided into 60 wards, with each ward having public representatives called corporators and a head named Mayor, the president of the municipal corporation. According to the 2011 census of India, the city corporation has approximately 6,00,000 population spread across an area of 170km2 with an average elevation of 22m above Mean Sea Level (MSL). The metrological and topographic details of Mangaluru City that can influence the complete MSWM system are presented in Table 6. The City has an evenly distributed sex ratio of about 50.2% males and 49.8% females, with 2843people per sq. km as its population density.

Table 6: Meteorological and topographical data of the study area		
Parameter	**Average value**	**Remarks**
Rainfall	4200mm	May to October period
Humidity	75.3%	62% in January 89% in July
Temperature	27°C - 34°C	Tropical climate
Wind	-	Moderate to gusty during day Gentle during night time
Topography	-	Highly undulating terrain
Geology	-	Hard laterite in Hilly terrain Sandy soil along sea shore
Earthquake zone	-	Seismic zone III

As with other cities in the country, Mangalore is a fast-growing city in education, commerce, IT, and industrial sectors; it imposes a great challenge for government bodies to implement effective SWM. Since openly dumped or uncollected solid waste can easily reach the sea through city drainage networks if SWM issues are not properly handled in coastal cities like Mangalore; it can pose a serious threat to the coastal environment (Becherucci et al., 2017). This can directly have an impact on marine life, which can decrease the major income source for many families and reduce tourism too.

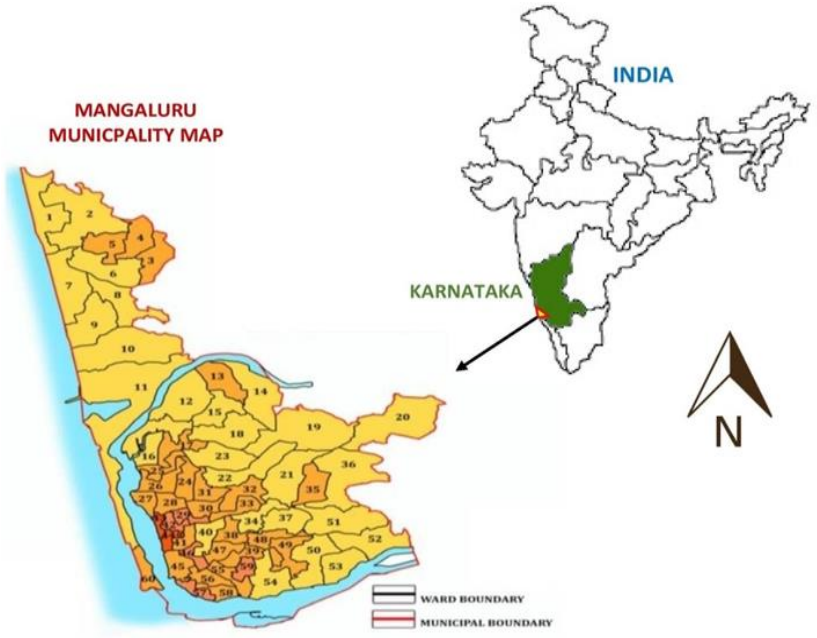

Figure 1: Mangaluru municipality ward map

3. Present Status of Solid Waste Management in Mangaluru

Every day, about 320 tonnes of MSW are generated in the Mangalore region, from which it is estimated to collect around 245 tonnes per day. Two methods of MSW collection followed in the region are door-to-door and community collection. An approximated statistic of the existing status of MSW generation and collection efficiency is given in Table 7. About 75.56% is the collection efficiency with the present system of MSW. Figure 2 presents the categorized 60 wards of MCC based on the Population Density Index (PDI). Residential developments, commercial complexes, biomedical, and industrial areas are four major sources of waste generation in Mangalore. It has been recorded that a major portion of collected MSW has its final endpoint at a scientific landfill site. Surprisingly, the percentage of waste dumped in landfills for the year 2014 - 15 was nearly 95% - 97% at Pachanadi within the corporation limit (Das, and Angadi, 2018). According to the researcher, only 50% of the MSW is segregated based on biodegradable and degradable properties (Sequeira and Chandrashekar, 2015). The garden trimming wastes are usually dumped for open composting, whereas waste papers are collected by local waste pickers for reuse. Some of the individuals were observed to dump their waste across the roads, mainly because of negligence or improper collection efficiency, creating a nuisance to the environment.

Table 7: Present status of MSW generation in Mangaluru

Sl No.	Particulars	Quantity
1.	Total projected population	746402
2.	Per capita waste generation (kg/day)	0.428
3.	Total waste generation per day (tons)	320
4.	Total waste collected per day (tons)	245
5.	Collection efficiency	76.56%

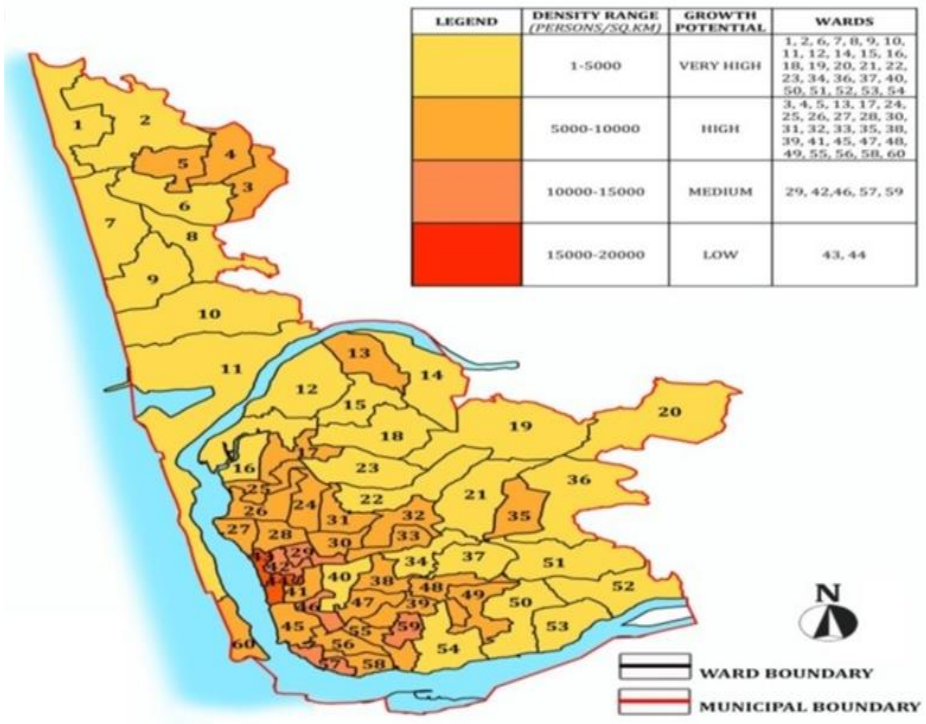

Figure 2: Mangaluru municipality ward map

The existing centralized transfer site or treatment yard is situated at Pachanadi, around 9km from the city. This yard is located on a hilltop near Vamanjoor Township and spreads across 37.2 acres (15.054 hectares). After door-to-door collection of MSW, it is transferred to this location using Twin containers and compactors (back and side loaders). Simple vermicomposting and aerobic windrow methods are used to convert biodegradable wet waste into a stable end product (manure). Automatic rotating sorting equipment is used to segregate non-biodegradable waste like paper, plastic, glass, metal, etc. At some locations in the city, MCC has biogas units where wet biodegradable waste is utilized for effective treatment. Finally, the inert wastes are disposed of at a sanitary landfill site. Figure 3 describes the flowchart of the existing solid waste management system followed in the Mangalore region.

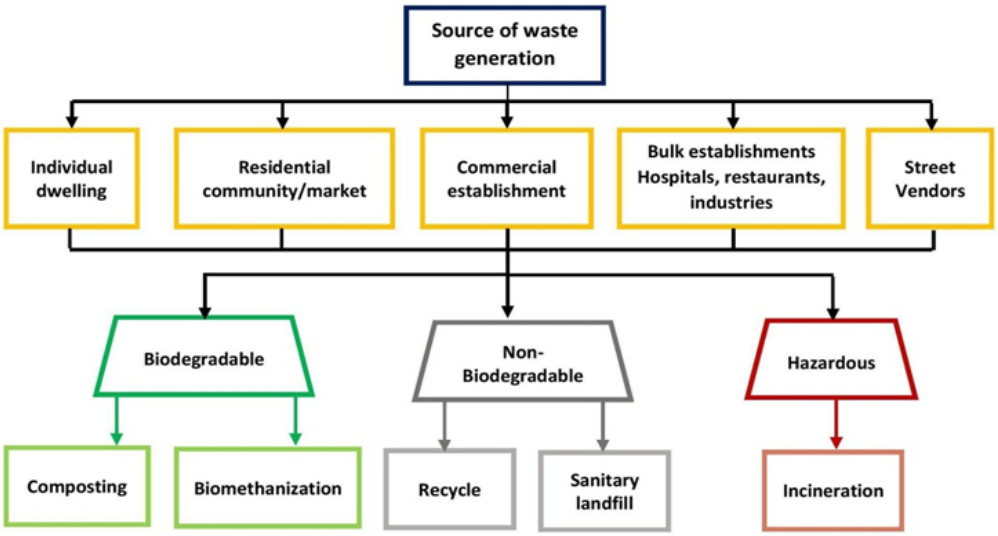

Figure 3: Flow chart representing present SWM system in Mangaluru

4. METHODOLOGY

In the present work, no experiments are conducted. The relevant data required for the study is collected from the respective authorities and the public and later analyzed using statistical tools. Based on various literature reviews, a structured questionnaire was prepared to collect and analyze the people's perceptions, participation, concerns, and involvement in the MSWM of Mangaluru. This survey was performed during the month of November in the year 2019 for Mangalore Municipal City Corporation limits. The questionnaire comprised three criteria.

I. Awareness and concern of people about the SWM system,

II. Understanding of the current SWM system in Mangaluru, and

III. People's perceptions, participation, and involvement of people, including the attitude of the "Not in My Backyard (NIMBY)" syndrome.

The questionnaire was circulated to the people categorized based on the attributes like age, gender, education level, and income range of residents. In order to effectively execute the survey, the study area of the Mangalore region was divided into two zones (north and south). The northern region consisted of most of the industrial developments and residential areas, while the southern zone had most of the colleges and residential areas. Before commencing the questionnaire survey, the local population was meticulously studied and categorized based on a few parameters. The sample to be surveyed was determined based on the Taro method, a scientific method for research based on surveys (Issam et al., 2014; Haider et al., 2015), and its mathematical representation is given by

$$n = \frac{N}{1+Ne^2} \quad (1)$$

Here, the total sample is represented as n, N represents the total household counts in the study area (82,925), and the level of precision is denoted by e. For the current survey, the level of precision was taken as ±9 with 2% confidence or risk level. Through the above-mentioned available data, the sample size was estimated and found to be 205, representing 205 households in the study region. In order to distribute the sample across the study area, two zones were selected (north and south). For each zone, 205 samples were considered, making a total of 410 samples. The representation of methodology is presented as a flowchart form in figure 5. The study starts with a reconnaissance survey (a preliminary city survey), followed by interviewing the residents using a structured questionnaire.

After drafting the questionnaire, the scientific personnel are asked to interview the individuals and collect their opinions, knowledge, and views regarding the SWM system in their locality. Since some of the parameters like age, gender, literacy, and economic status have a direct influence on perception and attitude, the utmost care was taken to spread the sample across the distribution. These parameters were also statistically assessed to understand the sample distribution.

Figure 4: Treatment site facilities

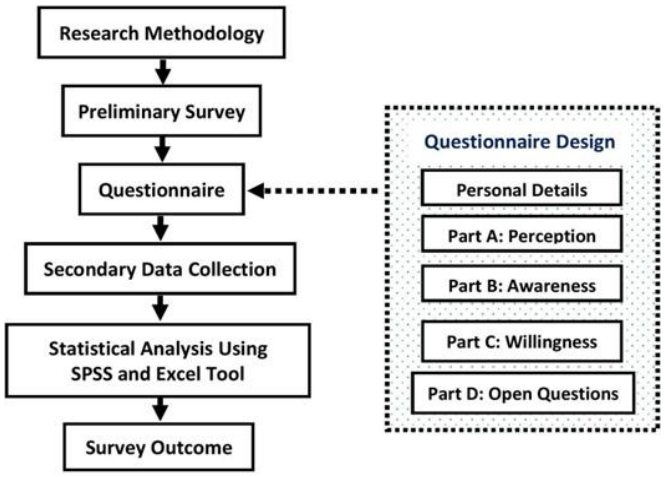

Figure 5: Research methodology flow chart

5. CASE STUDY RESULTS AND DISCUSSION

As discussed in previous sections, the success of SWM depends on public awareness, perception, concern, participation, and involvement in handling solid waste. Without the complete involvement of 194 houses, it would be a strenuous job to achieve the goal of "wealth from waste" As per the Taro method, a sample size of 410 citizens was questioned through written questions from both the study zones (north and south) of Mangaluru city. Individuals were provided with a set of 30 questions in English or Kannada (the local language) for better understanding. Tables 10 and 11 show a structured and detailed set of questions and the

consolidated responses and opinions of people collected during the survey. The age data of interviewed personnel is shown in Figures 6 and 7 for the north and south zones, respectively. With respect to age for reliable responses, the age range of 16 to 65 years was chosen. It was observed that the average age of the respondents was 41 years for the north zone region and 43 years for the south zone region. A marginally higher percentage of female respondents was interviewed, particularly 57% and 54% of the female count in the north and south regions, respectively, compared to 43% and 46% of the male count. Figures 6 and 7 clearly showcase the citizen age with gender distribution, reinforcing the reliability of the selected sample.

The economic status of any locality plays a major role in determining the quantity and quality of the solid waste generated. Apart from the characteristics of solid waste, even perception, awareness, and participation depend on economic status. Based on family income status, the respondents were grouped into three classifications: low (0 - 3 lakh), middle (3 - 6 lakhs), and high (above 6 lakhs). According to the survey, it was observed that 64%, 27% were high-income status respondents, 48% to 52% fell under middle-income status, and finally, low-income levels were 18% and 21% respectively, for the north and south zones. Hence, it is noticed that the majority of the individuals surveyed belong to middle-class families, with a fairly equal number of high- and low-income individuals. The figures 8 & 9 presents the histogram plots that reveal the distribution of representative samples.

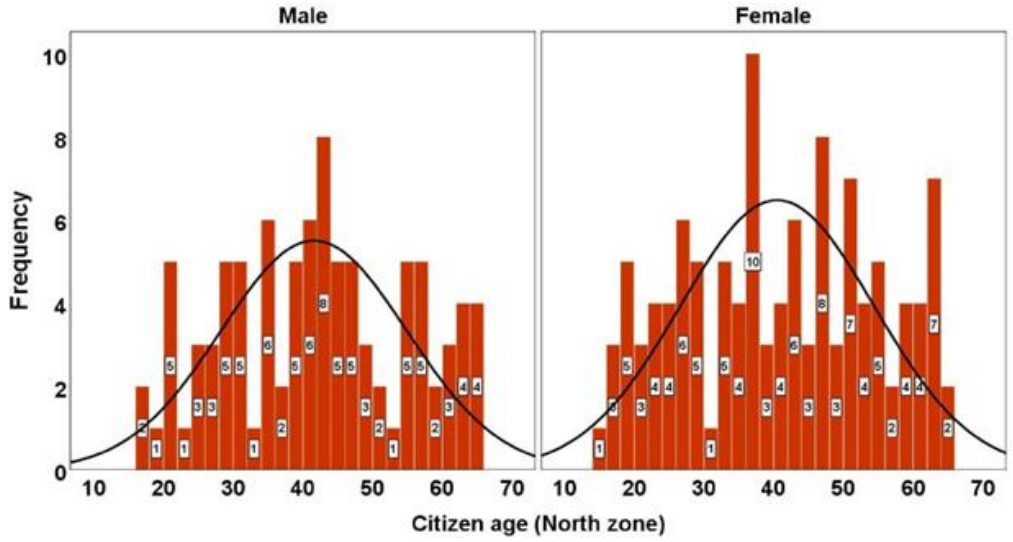

Figure 6: Frequency distribution histogram of citizen age group (North zone)

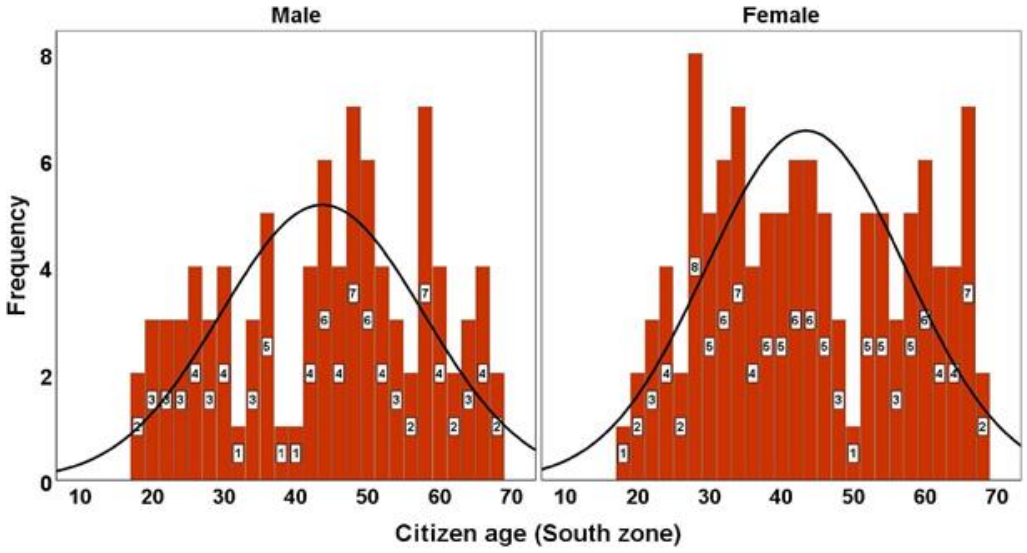

Figure 7: Frequency distribution histogram of citizen age group (South zone)

Table 8: Statistical analysis of surveyed citizen age group

Particulars	Age (N zone)	Age (S zone)
Sample	205	205
Mean	40.99	43.51
Median	41.00	43.00
Mode	46.00	57.00
Standard deviation	13.635	13.933
Variance	185.93	194.14
Range	50.00	50.00
Sum	8403.00	8921.00
N - North, S - South		

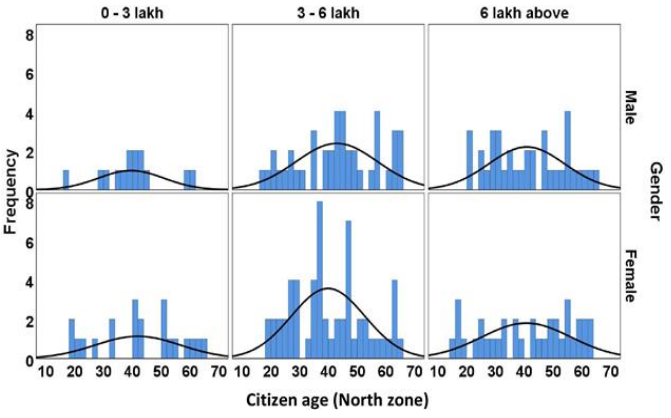

Figure 8: Frequency distribution histogram of income level (North zone)

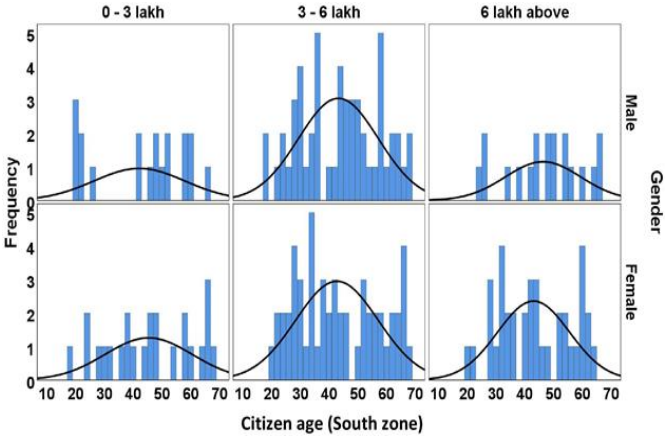

Figure 9: Frequency distribution histogram of income level (South zone)

The education level of the respondents is one of the prime factors that determine their perception and participation in MSWSM. To have a better understanding of the survey, the education level is broadly classified into three levels: no schooling level education, school level education, and college level education. If a person has not been to any school, they fall under no schooling level. If a person has attended school between the 1st and 10th standard, they fall under the school level. While the pre-university and bachelors or higher degree levels are referred to as college-level education. So it was noticed that 43% and 37% public from the north and south zones had college-level education, 41% and 50% from the north and south zones attained schooling education, respectively. 16% and 13% from the north and south zones, respectively, had no educational background during the survey. Figures 10 and 11 represent histogram plots that considered literacy data, age, and gender to understand the nature of the sample selected for the questionnaire survey. It was noticed from the plots that most of the respondents interviewed for this survey had some kind of educational background, except for a very few with no schooling level.

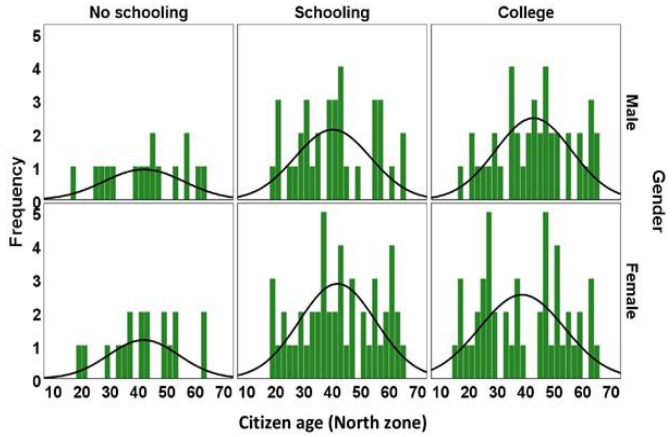

Figure 10: Frequency distribution histogram of literacy rate (North zone)

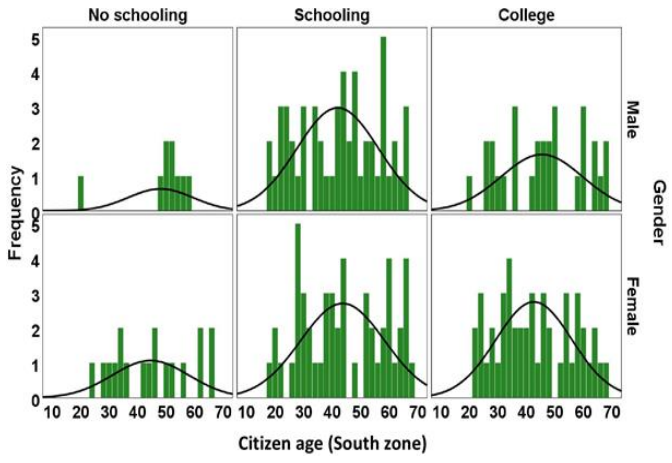

Figure 11: Frequency distribution histogram of literacy rate (South zone)

5.1 Public Willingness To Keep The Community Clean

From our preliminary survey and questionnaire survey, it was evident that a good door-to-door collection facility exists in the Mangalore region (Figure 13). It is observed that 85-90% respondents from the north zone had everyday collection systems in their locality, while only 60 – 65% respondents from the south zone admitted to having everyday collection systems (once every two days or twice a week). Due to the negligence of a few residents, open dumping was frequently observed in some of the fixed locations in both zones. Since there is a lack of door-to-door collection systems in the south zone, open dumping of solid waste across the road is a common sight for travellers. The frequent locations of the north and south zones where the open dumping of solid waste is witnessed regularly are presented in Figure 12. Hence, the respective authorities should take the necessary action to clean up and reduce the open dumping of solid waste in both the south and north regions of Mangalore city.

Figure 12: Illegal open dumping

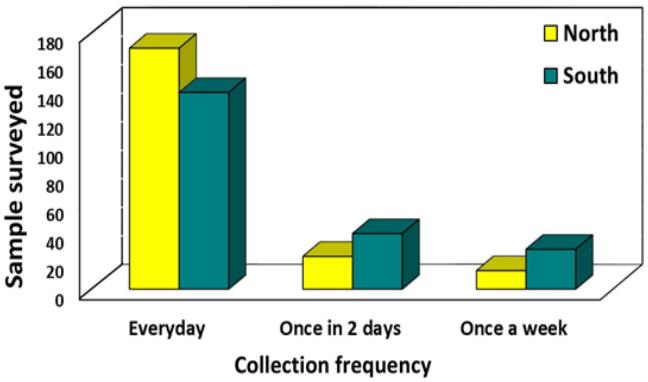

Figure 13: Frequency of MSW collection survey

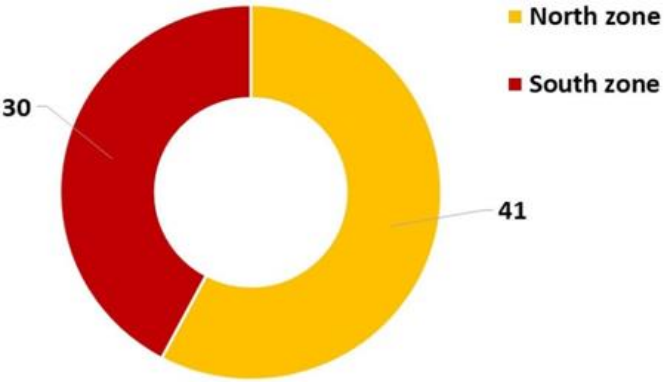

Figure 14: Reported health issues and nuisance due to open dumping

When asked about the legal and health consequences caused by open burning of solid waste, 90% of respondents from the north zone and 75% respondents from the south zone were aware of them. Additionally, 25% and 35% of respondents from the north and south zones claimed to have witnessed the open burning in their locality. If waste bins are placed at any location, then improper disposal of waste poses a big threat to the surrounding environment. (Figure 14) It can be noticed that about 41 people from the north zone and 30 people from the south zone reported open dumping and open burning activities near their locality. This statistic states that environmental officials have to take necessary action on such illegal activities in their respective wards. It is the responsibility of each and every citizen and stakeholder to act responsibly and work together for an effective SWM system.

5.2 Lack Of Accountability Within The System

The main reason for the unreliable and substandard service of SWM is the lack of accountability of unsupervised officials and community representatives. The motivation and interest of the elected representative play a significant role in the success of the SWM system. From the planning stage itself, all categories of residents must be involved in group meetings and committee formation. It is quite commonly observed that, over and over, the workers take things for granted and tend to commit mistakes knowingly. It is observed from the studies that involving the private sector for the waste collection stage on a contract basis with the government can drastically reduce the collection cost (Seth et al., 2014). The policymakers can also have an agreement between the government and agents stating rights, responsibilities, and obligations towards SWMS. The collection system has to be strictly observed or tracked in order to avoid illegal dumping. Since door-to-door collection facilities were not widely practiced in the south region, it was mainly observed that below 10% of the localities in this zone had waste collection bins for dumping solid waste. Installing waste bins cannot be the final option for collecting solid waste, but in order to reduce illegal dumping where there is no door-to-door collection facility, this can improve the existing condition.

5.3 Willingness To Pay For Unwanted Material

The competence of the existing SWM system directly has an impact on the willingness to pay for it. This is mainly dependent on the motivation of the stake- holders for the efficiency of the service. If the system is working most efficiently and effectively, even the residents will be most likely to be willing to pay for managing their waste. The payment and structure of the tariff should be clearly drafted so that end users can accept the official notice. It will be ideal if the tariffs are decided based on waste quantity and quality. Similarly, the service and handling charges can also be fixed based on the same parameters. The serious issue that always arises for any municipality is a lack of funding for effectively managing solid waste. The municipality cannot be blamed completely since it is responsible for all the stakeholder groups to work collaboratively based on region-specific issues.

The income generated from the reuse and recovery of solid waste will not be sufficient to manage the labour salary and unit maintenance costs. Less cost recovery could directly have a negative impact on the reliability of the service. About 70% respondents from the north zone and 50% respondents from the south zone were willing to pay the additional fee for a reliable and effective management system. While other residents refuse to pay the additional fee, they give two main reasons: i) residents said through tax they are already paying the maintenance cost that included solid waste handling, and ii) a lack of trust in the service provider and officials. These issues can be easily solved by actively involving the public in the planning and implementation stages of any solid waste management system. Ultimately, the government and local bodies should have a structure for planning the costs required for managing the SWM system.

5.4 Awareness Regarding The Programs And System

Creating awareness among the residents about the various processes and programs involved in SWM systems can have a greater impact on the management system. So the responsibilities of the stakeholders (government, policymakers, and citizens) are crucial factors in SWM. For the improper management of any solid waste, a municipality alone cannot be held responsible. It takes the collaborative work of all the stakeholders to make the system work smoothly. During the interaction, it was noticed that nearly 80% of the residents from the north zone and south zone had some idea about the existing solid waste management system in Mangalore. When asked about the cause of health effects due to improper management of solid waste, about 74% of people in the north zone and 64% people in the south zone were aware of it. 91% from the north zone and 78% people from the south zone were aware that open burning and dumping are illegal and can be punished under the environmental act.The management of solid waste has to start from the place of its generation, which means that waste of different kinds has to be segregated so that it can be treated accordingly. Even though respondents knew about it, only 64% from the north zone and 45% from the south zone involved themselves in segregating the waste at the time of generation. This must be taken into consideration, and necessary programs have to be planned to educate the end users about the importance of segregation in solid waste management systems. The location of existing treatment and dumping facilities in the Mangalore region was known to most of the respondents, particularly 98% from the north zone and 83% from the south zone. Also to be noted is that 25% of the residents had no idea about the treatment techniques of MSW. When enquired about the waste disposal techniques, nearly 72%, and 67% of people in the north and south zones, respectively, were aware of the concept. Finally, the respondents from both the north and south zone regions (98% and 88% respectively) showed greater interest in the addition of environmental education at the school and college levels.

5.4.1 Awareness Towards 4R's

During the survey, when asked about the 4 R's (Reduce, Reuse, Recycle, and Recover), most of the respondents were aware of the concept. About 70-80% of both north and south zone respondents had some idea about the 4R concepts, while 13-15% of residents had no idea about the recovery concepts from the waste. It is to be noted that the residents with a higher level of education had a better understanding of the recovery practices for solid waste than the rest. When enquired about the use of reusable bags for regular shopping practices, nearly 59% of residents in the north zone and 53% of residents in the south zone already practiced the use of reusable bags. Hence, awareness has to be created among the residents about reuse and recovery with special incentives to reduce the load for treatment at landfill sites. The understanding of the public about the recovery, recycle, reuse, and reduce concepts are presented in Figure 15. Almost the same pattern of response was observed when both the north and south regions were compared.

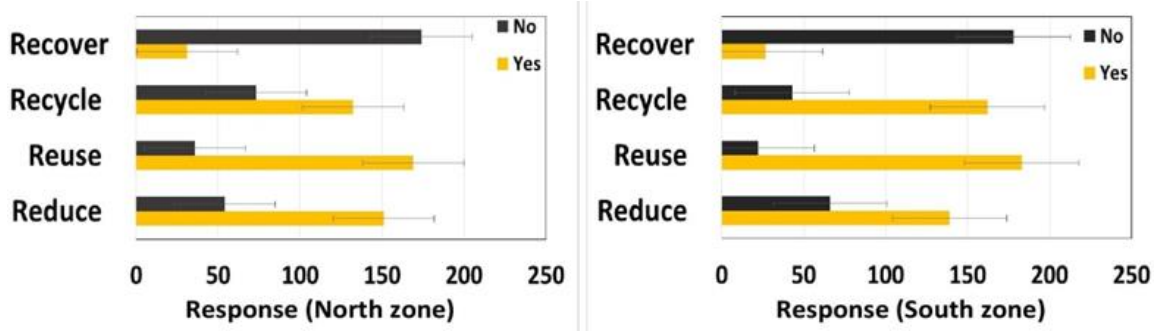

Figure 15: Awareness about 4R concept

5.5 Willingness To Participate In Solid Waste Management Initiatives

The willingness to participate in SWM initiatives was 90% for north zone residents and 70% for south zone respondents. Several Non-Governmental Organizations (NGOs) and private organizations like Ramakrishna Missions, along with Mangalore Swatch Bharath initiatives, were effectively involved in regular collections, cleaning, and maintaining localities hygiene in public places on most weekends. These initiatives were successful in most of the wards of Mangalore and improved environmental conditions. Such initiatives should be recognized and encouraged by the state and central governments to boost their interest and motivate them towards a better cause.

5.6 Acceptance For Building Facilities Near Their Locality

Due to the lack of awareness about the treatment systems, especially recycling units or incineration of MSW, only one-fourth of total respondents showed a positive response towards incineration plants, and about one-third of respondents showed a positive response to constructing a recycling unit in their locality. It is very evident and understood that most of the citizens were not open-minded enough to accept the treatment facility, which they feel may create a nuisance in their locality. This can also be due to the unplanned treatment of the present landfill facility. Most interestingly, it was observed that the respondents who objected to the treatment or recycling system were from the younger generation. This indicates that the top priority has been given to the

awareness program and environmental education about the SWM system among the younger generation.

5.7 Overall Perception Of Existing SWMS In Mangaluru

Most of the respondents provided positive responses, with few suggestions on the future collection and treatment facilities for solid waste. The questionnaire was categorized into five opinion levels: extremely satisfied, satisfied, somewhat satisfied, unsatisfied, and don't know. From the responses to the survey, it was evident that the residents of the north zone were more satisfied than the south zone residents because of the most efficient collection system in the north zone region. About 75% of the North Zone respondents and 50% of the South Zone respondents were satisfied with the existing SWMS (Figure 16). In fact, average and below-average opinions about the SWM system were more common among south-zone respondents. This study will provide the reason for the officials to take the necessary action about the region of lowered opinions to improve the SWM system. It is also interesting to know that nearly 10% of the residents from both the north and south zones had no knowledge about the prevailing system of solid waste management.

The performance indicator can be used to understand and analyze the performance of any sector through the opinions of stakeholders. The approach will reflect financial performance, organizational capacity, system efficiency, and other factors. Usually, it can be calculated by choosing managers or from a citizen's perspective. The service level benchmark evaluation of the existing solid waste management facility in Mangalore City is estimated and presented in Table 9. From the analysis, it is clear that the system needs improvement in the collection, treatment, and disposal systems for effective SWM.

Table 9: Service level benchmark indicators of SWM system

Sl No.	Indicators	Benchmark	Status
1.	Household level coverage of solid waste management	100%	40%
2.	Efficiency of collection of municipal solid waste	100%	90%
3.	Extent of municipal solid waste recovered/recycled	80%	70%
4.	Extent of Scientific disposal of municipal solid waste	100%	30%
5.	Extent of cost recovery in solid waste management	100%	15%
6.	Efficiency in redressal customer complaints	80%	70%
7.	Efficiency in collection of user charges	90%	30%
Source: SLB notifications of Karnataka ULB'S 2011			

5.8 Awareness programs

The most effective way to reach the maximum number of stakeholders can be by including environmental education at the regular school or college level as a part of the curriculum. The Swatch Bharath Mission was given prime priority by most of the educational institutions in and around Mangalore, which worked towards a cleaner India. Additionally, the state university in the Mangalore region has transformed its work culture to reduce the solid waste generation on its campus through sustainable and greener initiatives (Sanjith et al., 2018). This was achieved by encouraging online documentation, two-sided printing, etc. The residents should be educated regarding the solid waste system, especially the segregation of solid waste at the generation level itself. The major challenge of treating solid waste will be tackled easily if the waste is segregated at the generation level. If possible, the present mass media platform can be chosen to reach as many stakeholders as possible and raise awareness about the MSWM System. Similarly, social media can be effectively utilized to spread regular updates on the existing waste management system. This approach can reach the majority of the population since it is a booming platform these days. Elected representatives from the corporation level to the state level with government environmental officials can involve in spreading awareness campaigns. A discipline surveillance committee should be working effectively to check if anyone is violating the MSW rules. If found guilty, the penalty has to be imposed on that individual for his or her crime. The government should encourage private start-ups or companies that show interest in collecting and treating solid waste.

Table 10: The overall outcome of the respondent's opinion

Region	1	2	3	4	5
North	85 - 90%	90%	70%	98%	40%
South	60 - 65%	75%	50%	88%	25%
1: Door-to-door collection, 2: Open burning Offense, 3: Pay for the system, 4: Awareness of SWM, 5: Acceptance of Treatment Facility					

6. Conclusion and Recommendations

The study showcased the existing practices and status of solid waste management in the Mangalore region, with reinforcement of public perception and attitude. The existing practices of the Mangalore solid waste treatment plant are observed to be similar to those of other cities across the country, which have similar per capita generation. It is clearly noticed that as the city is growing at a rapid pace, the quality and quantity of the solid waste generated are also varying. From the survey, it was observed that the Mangalore solid waste treatment facility is also facing technical, organizational, and economic challenges for the smooth operation of solid waste management. The smooth operation of solid waste treatment facilities can directly reduce land pollution, reduce health risks, and minimize the pollution of coastal ecosystems as well.

The survey data, the outcome of the in-depth interview, and the secondary data from the government bodies are synthesized to draw a conclusion on the existing solid waste management facility in the Mangalore region. The sample size of 410 was determined based on the widely accepted and reliable Taro Yamane method. Utmost importance was given to sample distribution, hence the histogram plots representing respondents' age, educational background, gender, and economic status is plotted for better understanding. By referring to various literatures, a constructive questionnaire was developed that included the perception, attitude, and opinion of the respondents residing in the Mangalore constituency.

The residents of the Mangalore region participated in the survey with utmost interest and effectiveness. The northern zone respondents suggested that the existing solid waste management was good, but it was reduced to a satisfactory level compared to the southern zone opinions. Table 10 presents a statistical outcome of an interview on public perception and their opinion for significant questions from the north and south zone regions. Most of the participants suggested including the goodwill of people for managing and taking better decisions while planning solid waste management.

To tackle the solid waste management issues on an immediate basis, community bins can be placed in a specified location with regular collection and maintenance of the area around them. To observe significant changes in solid waste management, the residents have to be educated to segregate the wet waste from other types of dry waste before handing it over to the collection vehicles. But, since it is a long process to educate each and every individual, other technological facility have to be adopted in the final treatment and dumping facility. The major challenge observed in the final treatment facility was to separate the mixed biodegradable and non-biodegradable substances before treatment. Once the separation process is effectively performed, the biodegradable substance can be easily treated by aerobic composting or vermicomposting techniques. This will drastically reduce the excess load of biodegradable substances over landfills and can also reduce the leachate forming through them. Further, a scientific approach has to be adopted for operating the sanitary landfill. Some of the key recommendations are listed below,

I. A structured education policy has to be introduced to spread awareness among upcoming generations.

II. Plans to provide incentives that can encourage recycling practices

III. Planning stages can be effective only if residents are involved from the preliminary stage.

IV. The awareness campaigns must target local institutions and organizations.

V. Any development project in the locality must undergo a compulsory environmental clearance or impact assessment before its implementation.

VI. The official should take the necessary action to revise the existing MCC

environmental policies according to present-day needs.

VII. Stakeholders must be involved on a regular basis, at least once a year, through summits or workshops to monitor and improve the on-going system.

Ultimately, the survey on public perception and attitude towards solid waste management facilities in the Mangalore region was effectively concluded and was relatively successful in documenting the present status. This approach can be adopted in various cities across the world to economically understand the existing situation of the solid waste system. The forthcoming task of MCC should be to gather suggestions from particular localities and act according to government policies. Based on the further prediction of the solid waste generation rate, a customized treatment technique can be designed and implemented to effectively reduce the load on sanitary landfills.

Table 11: Consolidated north zone questionnaire

Sl No.	Questionnaire		Yes	No	Percentage	
					Yes	No
1.	Are you aware about generation of solid waste and disposal	-	176	26	87.31	12.69
2.	Involvement in segregation of waste at the source	-	132	73	64.39	35.61
3.	Any form of bad smell and nuisance/health problem noticed in your Ward/Area	-	41	164	20.00	80.00
4.	Present way of handling SW	Self	59	146	28.78	71.22
		MCC	146	59	71.22	28.78
5.	Does the collection happen on regular basis	-	190	15	92.68	07.32
6.	How often is the waste containers emptied	Everyday	169	36	82.43	17.57
		1^{s} in 2 days	23	182	11.22	88.78
		1^{s} in a week	13	192	06.34	93.66
7.	Is the collection from MCC satisfactory	-	191	14	93.17	06.83
8.	Awareness about use of waste in	HC	86	119	41.95	58.05
		VC	79	126	38.53	61.47
		SL	158	47	77.07	22.93
9.	Awareness regarding health issues	-	152	53	74.14	25.86
10.	Have you ever been educated on proper waste disposal by the council	-	149	56	72.68	27.32
11.	Do you know environmental effect of SW	-	183	22	89.26	10.74
12.	Awareness about peoples involvement	NGO	171	34	83.41	16.59
		RM	86	119	41.95	49.05
13.	Awareness about 4R'S	Reduce	151	54	73.65	26.35
		Reuse	169	36	82.44	17.56
		Recycle	132	73	64.39	35.61
		Recover	31	174	15.12	84.88
14.	Awareness about scrap shop	-	128	77	62.44	37.56
15.	Are you going to sell paper, plastic and metals to scrap shop	-	119	86	58.04	41.96
16.	Do you know what happens to waste after it goes out of your home	-	167	38	81.46	18.54
17.	Do you follow the instructions of MCC/Govt or NGO to carry your own bag to shopping	-	121	84	59.02	40.98
18.	Is burning of garbage illegal? Will it have any impact on health and environment	-	187	18	91.22	08.78
19.	Have you seen any illegal dumping of SW in your Ward/Area	-	46	159	22.44	77.56
20.	Are there any public bins near your house	-	31	174	15.12	84.88
21.	The attitude of NIMBY (Not In My BackYard)	-	127	78	61.95	38.05
22.	Are you creating awareness among your children / family about SWM	-	198	7	96.58	03.42
23.	Do you think environmental education and SWM should be thought at school level	-	201	4	98.04	01.96
24.	Do you know where the waste is treated	-	202	3	98.53	01.47
25.	Should municipality charge penalties on open dumping of waste	-	188	17	91.70	08.30
26.	Opinion of building incinerator near their locality	-	30	175	14.63	85.37
27.	Views regarding having recycling unit near their society	-	71	134	34.63	65.37
28.	Do you think reducing solid waste issue can reduce most environmental concern	-	193	12	94.14	05.86
29.	Are you willing to pay for MSWM	-	143	78	69.75	30.25
30.	Overall opinion about SWM from MCC	Satisfied	167	38	81.46	18.54

HC - Home composting, VC - Vermi-composting, SL - Sanitary Landfill,
RM - Ramakrishna Mission

Sl No.	Questionnaire		Yes	No	Percentage	
					Yes	No
1.	Are you aware about generation of solid waste and disposal	-	158	47	77.07	22.93
2.	Involvement in segregation of waste at the source	-	91	114	44.39	55.61
3.	Any form of bad smell and nuisance/health problem noticed in your Ward/Area	-	30	175	14.63	85.37
4.	Present way of handling SW	Self	139	66	67.80	32.20
		MCC	66	139	32.19	67.81
5.	Does the collection happen on regular basis	-	141	64	68.78	31.22
6.	How often is the waste containers emptied	Everyday	124	81	60.48	39.52
		1^{s} in 2 days	23	182	11.22	88.78
		1^{s} in a week	13	192	06.34	93.66
7.	Is the collection from MCC satisfactory	-	165	40	80.48	19.52
8.	Awareness about use of waste in	HC	92	205	44.87	55.13
		VC	29	176	14.14	85.86
		SL	41	164	20.00	80.00
9.	Awareness regarding health issues	-	141	64	68.78	31.22
10.	Have you ever been educated on proper waste disposal by the council	-	138	67	67.31	32.69
11.	Do you know environmental effect of SW	-	178	27	86.83	13.17
12.	Awareness about peoples involvement	NGO	162	43	79.02	20.98
		RM	104	101	50.73	49.27
13.	Awareness about 4R'S	Reduce	139	66	67.80	32.20
		Reuse	183	22	89.26	10.74
		Recycle	162	43	79.02	20.98
		Recover	27	178	13.17	86.83
14.	Awareness about scrap shop	-	143	62	69.75	30.25
15.	Are you going to sell paper, plastic and metals to scrap shop	-	189	16	92.19	7.81
16.	Do you know what happens to waste after it goes out of your home	-	134	71	65.36	34.64
17.	Do you follow the instructions of MCC/Govt or NGO to carry your own bag to shopping	-	109	96	53.17	4.83
18.	Is burning of garbage illegal? Will it have any impact on health and environment	-	161	44	78.53	21.47
19.	Have you seen any illegal dumping of SW in your Ward/Area	-	68	137	33.17	66.83
20.	Are there any public bins near your house	-	17	188	08.29	91.71
21.	The attitude of NIMBY (Not In My BackYard)	-	39	166	19.03	80.97
22.	Are you creating awareness among your children / family about SWM	-	173	22	84.39	15.61
23.	Do you think environmental education and SWM should be thought at school level	-	182	23	88.78	11.22
24.	Do you know where the waste is treated	-	172	33	83.90	16.10
25.	Should municipality charge penalties on open dumping of waste	-	139	66	67.80	32.20
26.	Opinion of building incinerator near their locality	-	42	163	20.48	79.52
27.	Views regarding having recycling unit near their society	-	48	157	23.41	76.59
28.	Do you think reducing solid waste issue can reduce most environmental concern	-	144	61	70.24	29.76
29.	Are you willing to pay for MSWM	-	97	108	47.31	52.69
30.	Overall opinion about SWM from MCC	Satisfied	146	59	71.22	28.78

HC - Home composting, VC - Vermi-composting, SL - Sanitary Landfill,
RM - Ramakrishna Mission

NOMENCLATURE

CPCB	Central Pollution Control Board
CPHEEO	Central Public Health & Environmental Engineering Organization
HC	Home composting
INR	Indian Rupees
MCC	Mangaluru City Corporation
MM	Mangaluru Municipality
MSL	Mean Sea Level
MSWM	Municipal Solid Waste Management
N	North
NEERI	National Environmental Engineering Research Institute
NIMBY	Not In My Back Yard
PSP	Private Sectors Participation

RM	Ramakrishna Mission
S	South
SL	Sanitary Landfill
SLB	Service Level Benchmark
SWM	Solid Waste Management
SWMS	Solid Waste Management System
ULB	Urban Local Boundaries
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
VC	Vermicomposting

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