

Public Perception and Concern Towards Solid Waste Management: A Case Study of Mangaluru City, India

Sanjith S Anchan (✉ sanjithsj@gmail.com)

National Institute of Technology Karnataka <https://orcid.org/0000-0002-0075-1942>

Palakshappa K

PA College of Engineering

Research

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Abstract

Rapid increase in Municipal Solid Waste (MSW) generation and varying characteristics is posing great threat to most of the cities across the globe. The present paper deals with evaluation of current status of Municipal Solid Waste Management System (MSWMS) in Mangaluru, and explores the perception, opinion and attitude of the citizens. In view of the present study, a feedback survey from 410 valid respondents representing separate households was collected. The statistics of the data were analyzed using SPSS and MS Excel tools. It is evident from the results that, the existing solid waste management practice does not match the anticipation of the citizens and involvement of the citizens in the solid waste management is not satisfactory. The major findings of the survey reveal that, there is a need for improvement of solid waste management of Mangaluru with active participation of citizens, policy makers and all stakeholders.

1. Introduction

Municipal Solid Waste (MSW) also known as thrash are resulted from diverse human activities is an inevitable part of all society. The rapid increase in population with diverse human activities has led to an alarming increase in municipal solid waste generation. The MSW generated is posing a great threat to the public health, environment and economy of cities in developing countries [1, 2]. Municipal Solid Waste Management (MSWM) is a challenging task in cities with high population density. India being a country with diverse culture, many different religious groups and traditions SWM becomes more complex and challenging to be effectively solved. Environmental pollution, spread of diseases, land occupation and unpleasant aesthetics are some of the major negative impacts of poor Solid Waste Management (SWM). Apart from causing air pollution (in the form of inorganic particles and foul odour) MSW constituting non-biodegradable solid waste causes severe soil pollution. A list of pollutants and its impact on air, soil, water has been clearly presented in Table 1. Hence SWM has become a multidimensional issue that involves political, social, environmental and economic aspects [3].

Table 1
Environmental impact summary on account of various waste technologies [9]

Pollutants origin from respective waste technologies				
Domain	Composting	Incineration	Dumping Landfills	Recycling
Air	Odour, GHG emissions	SO ₂ , NO ₂ , HC, 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 emission	Leachate, heavy metals	Processing wastewater

MSW has been interpreted in various theoretical definitions. Vergara et al. stated “MSW are one such waste that comprises all solid and semi-solid materials generated from residential and public locality excluding hazardous and wastewater in it” [4]. It is also described as materials that have no value to the holder [5]. Anthropologists view it as a factual evidence of civilizations and their life style [6]. Industrialist describes solid waste as right thing at wrong place [7]. Meanwhile ecologist believes that there is no waste in nature. These MSW are usually made up of organic and inorganic substances and recyclable materials.

Estimating the quantity of MSW generated is the key factor for waste management planning. Especially in developing countries managing solid waste will be a crucial challenge due to changing composition, limited policy frameworks and escalated waste management cost. There are various factors like population density, standard of living, environmental conditions, extent and level of commercial activities, seasons and eating habits deciding the quantity of waste generation in any location. In India waste generation is recorded to be varying from 0.17 to 0.62 kg per capita per day. Table 2 presents the generation of solid waste statistics against the cities grouped according to their population [8].

Table 2
Waste generation rate of Indian cities [8]

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

One of the important aspects to be understood is the characteristics of MSW that govern the waste-processing technologies [9]. Waste characteristics will be directly affected by standard of living, climatic and topographical conditions, cultural rituals, economic status, and kind of energy sources and literacy rate of locality [10]. Especially country like India being diverse in its culture, religion, rituals and fast growing will exhibit extreme variation of MSW characteristics [11]. Recently people are tending towards more of electronic goods, which have led to great increase of e-waste in characterization [9]. The composition of MSW as per recorded by Arceivala and Asolekar (2012) is presented in Table 3. It is comprehensively understood that wet waste (food and kitchen waste) contributes nearly 50% of MSW with highest composition, followed by inert waste and other categories. Indeed, it is also supported by the study recorded by Central Pollution Control Board-National Environmental Engineering Research Institute (CPCB - NEERI) as shown in Table 4. Here the calorific value indicates the heat produced by complete combustion of respective waste in specific quantity. Whereas percentage of water content in solid waste is recorded as moisture content. High calorific values indicate better and more effective adoption of waste to energy treatment techniques [12]. It is important to be noted in India that 40–50% of recyclable waste is managed by vast informal sector for their livelihood.

Table 3
Representative composition of MSWs in India cities [34]

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.Inert	20–50

Even-though the concept of solid waste is not new to mankind, complexity in modern era has made SWM a major issue. Advancement in technology and civilization has transformed MSW into a more complex substance. It has been so due to excess generation of e-waste [13]. In an advanced world a product can be developed in one country and discarded in another country. This can cause inconsistency among regulations and policies regarding waste management and disposal [14]. Even though fundamental objective of any SWM system is to reduce the environmental pollution, with sustainable funding and local affordable technologies, lack of participation from public makes it ineffective. Private Sectors Participation (PSP) will only be successful if there is willingness to pay for waste management. Perhaps it could directly impact the integral system of SWM [15]. Primarily individual dwelling will be the starting location of any waste management activity [16, 4, 17].

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

Cities with population range	Net calorific values (kcal/kg)			Moisture (%)		
	Min	Max	Mean	Min	Max	Mean
Cities with population of 1–5 lakh	1591	3,766	2,162	24	63	50
Cities with population of 5–10 lakh	1591	2,391	1,481	17	64	48
Cities with population of 10–20 lakh	1520	2,762	1,411	25	65	41
Cities with population of above 20 lakh	1834	2,632	1,772	21	63	47
Source: CPCB-NEERI (2006)						

What public think about waste plays a significant role in SWM [18, 19]. Community involvement in activities like recycling, encouraging participation in decision making, waste segregation at source are

some key factors in SWM. Understanding the concept of MSW generation and management that includes control of generation, collection, transportation, treatment and disposal play a vital role in deciding people's perception and attitude towards SWM facility. Illegal waste dumping on streets, open spaces, drains is noticeable if basic waste collection facility at source is not provided by Urban Local Bodies (ULB). Although there exists several policies, rules and schemes regarding MSWM in India, it is the public participation that extensively decides the success of SWM. Table 5 presents various prominent rules, policies, schemes and financial plans on solid waste management in India.

Table 5
Important Rules, Policies, Schemes and Financial Schemes of SWM in India

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 MSW)
2008	National Urban Sanitation Policy Hazardous Waste Management Handling Transboundary movement Rules Service Level Bench Mark (SLBs)
2011	Plastic Waste Rules E-Waste Rules Draft Bio-medical Waste Rules
2014	Swachh Bharath Mission
2016	Waste Management Rules
	Construction and Demolition Waste Management Rules

Perception can be described as how a person sees himself and world around him with its governing behavior [20]. Similarly, attitude can be expressed as individual way of thinking. A positive attitude can be developed through imparting knowledge and educating public regarding environmental conditions. Citizens worldwide not willing to participate in source separation program can be a serious threat to environment [21]. Public assume that waste thrown on streets would be picked by local municipality. This mindset leads to unscientific system of waste management throughout India. For instance, cities with more citizen's involvement during planning process recorded higher rate of participation in product recycling [22]. Studies have recorded more than 91% of MSW collected across India find their way to dumping site either on open lands or dumps [23]. Hope still prevails in India if the citizens choose to manage waste within home and reduce the excess load of MSWM.

In order to understand the functionality of environmental governance and practices of MSWM, in the present study we explored people's attitude, perception and knowledge in connection with the present SWM system in Mangaluru city. Overall objective of study is also focused on investigating the concern of citizens towards SWMS. This study will help as an evidence for law making, governing bodies to implement effective SWMS and to bring awareness among communities. The outcome of the study also manifests behavioral variations that enrich citizen's response towards their responsibilities in developing city like Mangaluru. Furthermore, it encourages and educates the public for better SWM practices and increase the efficiency of the system. Collaboration among public and policy makers is very crucial to educate and provide innovative and most effective SWM system. Even the eminent International Organization (UNEP, 2004 and USEPA, 1995) outlook the citizen's perceptions, opinion and attitude raised through education.

The paper is organized as follows: A descriptive introduction on municipal solid waste, importance of waste management and brief about public attitude, perception is presented in first section. Second section presents the details of study area. It is followed by comprehensive discussion on the present status of solid waste management at Mangaluru in third section. Fourth section illustrates the methodology adopted for this study. A detailed case study is discussed along with results in fifth section. Finally, section six provides inferences and recommendations of the work carried out.

2. Study Area

Being the district headquarters Mangaluru city is located in Dakshina Kannada District of Karnataka state towards southern part of India. It is the second largest city of state situated between Arabian Sea towards west and Western ghats towards its east (12°47'N latitude and 74° 50'E longitude). The city has good connectivity through airport, harbor, railways and road networks linking various major cities within the country and across the globe. Mangaluru has been growing and expanding area-wise at a very fast rate [24]. Mayor being the president of municipal corporation, city has been divided into 60 wards each represented by a corporator. City corporation has registered more than 6,00,000 population (Census of India, 2011 [25]) and area of 170 km² with average elevation of 22 m above Mean Sea Level (MSL).

Table 6 provides the meteorological and topographical data of study area. The city has population density of 2843 people per sq. km., with sex ratio being 50.2% male and 49.8% female.

Table 6
Meteorological and topographical data of the study area

Parameter	Range	Remarks
Rainfall	4200mm	May to October period
Humidity	75.3%	62% in January, 89% in July
Temperature	27–34	Tropical climate
Wind	-	Moderate to gusty during day Gentle during night time
Topography	-	Highly undulating terrain
Geology	-	Hard laterite in Hill tracts Sandy soil along sea shore
Earthquake zone	-	Seismic zone III

Since Mangaluru is a fast-growing city in education, commerce and industrial sector, it faces a great challenge to effectively resolve the menace of SWM. A poor waste management in coastal cities like Mangaluru can directly lead to coastal zone management problems, since disposed solid waste can easily reach sea with drainage networks [26]. In addition it can also seriously damage marine life, ghost fishing indirectly decreasing tourism economy [27].

3. Present Status Of Swm In Mangaluru

The total generation of solid waste from Mangaluru is 320 tons/day out of which approximately 245 tons of MSW is collected per day. The method of collection is through door to door and community collection system. Table 7 presents the current status of MSW generation and collection efficiency of Mangaluru city. The collection efficiency is estimated as 75.56%. The 60 wards of Mangaluru city municipality are categorized based on Population Density Index (PDI) as shown in Fig. 2. Three major sectors contributing for MSW are municipality (residential and commercial), biomedical waste and hazardous waste from industrial sectors. Major part of the MSW is directly discarded to garbage collection trucks or local collection point. In the year 2014–15 around 95% – 97% of collected MSW waste ended up in landfill located at Pachanadi within the corporation limit [28]. Studies have also recorded that only 50% of waste is segregated at the source of generation based on degradable and non-degradable (recyclable) substances [29]. Most of the dry waste like garden trimming and paper are used for composting and burning in individual dwelling facilities. Few public who find dumping site far from their locality easily throw away the waste to open land that cause nuisance to 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%

Twin containers and compactors (back and side loaders) are used to transfer the waste to Pachanadi, a centralized treatment site, located at 9-km from the centre of the city. The treatment site is spread over an area of 37.2 acres at the hill top near Vamanjoor Township. The biodegradable substances in treatment site go through composting by vermi composting and aerobic windrow composting that reduce great load to landfill. A smaller quantity of wet waste is used by small scale bio-gas generation units located across the municipality and within the institutions. Some focused recyclable waste like metals; paper and glass are segregated using automatic waste sorting equipment's. Finally, the inert wastes find their way to sanitary landfill site. Like other cities informal recycling sector plays a vital role in minimizing the waste ending up into sanitary landfill. Figure 3 presents flowchart of current solid waste management system in Mangaluru. Figure 4 shows the existing treatment facilities like Vermi Composting (VC), Plastic segregation equipment and Sanitary Landfill (SL) in Pachanadi SW treatment and dumping site.

4. Methodology

Based on various literature reviews, a structured questionnaire was prepared to investigate the public concern and attitude towards MSWM facilities in Mangaluru. The questionnaire comprised of three sections as given below including basic attributes like age, gender, and education level and income range.

1. Concern about present prevailing SWM system.
2. Perception towards innovative, practical and effective SWM facilities.
3. Public attitude towards "Not In My Backyard (NIMBY)" syndrome.

The study area is divided into two zones (north and south) to execute constructive survey. The north zone of city consisted more of industrial area with residential sectors wherein south zone comprised of educational, medical and residential sectors. Prior to field survey, the local population was meticulously studied and categorized based on the criteria of standard of living, literacy rate and socio-economic factors. This categorization helped to collect required representative survey samples of the study area. The sample size was determined based on Taro method, a scientific methodology of survey research [30, 31] as follows

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

where, n represents the total sample size, N is the total count of households in the study area (82,925), and e signifies level of precision. In the present study the level of precision is considered as ± 9 with 2% confidence or risk level. Accordingly, the estimated sample size is found to be 205 representing 205 households of study area. In order to accomplish a productive survey the sample size of 205 were selected from both the zones independently (North and South) making it total of 410 sample size. Figure 5 presents the flowchart of research methodology that starts from preliminary city survey followed by a structured questionnaire design. After questionnaire survey, necessary secondary data were collected from authenticated sources and conclusion were drawn based on analysis of data.

Public were interviewed individually by scientific personnel and were requested to express their views and knowledge on SWM system near their stay and working locality. A pilot study was performed to verify the accuracy and precision of the survey. The collected data were analyzed statistically using IBM SPSS statistical software and Microsoft Excel 2013 on various data collected to understand the effectiveness of survey. Specifically, some parameters like age, gender, literacy and economic status of citizens had direct influence on individual perception and attitude. Hence, these parameters were assessed using statistical methods.

5. Case Study Results And Discussion

As discussed in previous sections, public perception and attitude plays an important role in solving the SWM problems. Without complete involvement of household personnel's it will be a strenuous job to achieve the goal of "wealth from waste". Accordingly, a total of 410 citizens were interviewed from both the study zones (north and south) of Mangaluru city. Individuals were provided with a set of 30 questions communicated in English/Kannada (local language) for better understanding. Table 10 and Table 11 provide a structured and detailed set of questions and consolidated opinion of participants during the survey.

The age data of interviewed personnel is represented in Fig. 6 for north and south zone respectively. The age bracket of 16 years to 65 years was considered for better understanding of SWM system at various age levels. Average age of respondents from north zone was 41 years and south zone was 43 years. The gender profile indicates marginally higher female constitute with 57% and 54% when compared to male count of 43% and 46% in north and south zone of study area respectively. The plot of citizen's age with gender (Fig. 6) clearly indicates the reliability of the sample. The samples were diversely distributed to comprehend the representative nature (see Table 8). The standard deviation calculated from data

analysis is 13.6 for north zone and 13.9 for south zone. Further the variance value is 185.93 for north zone and 194.14 for south zone.

The family economical status played a major role in determining the quantity and quality of the MSW. Individual annual income will directly have an impact on their perception and attitude towards MSWM system. The respondents were grouped into three income class namely low (0–3 lakh), middle (3–6 lakh) and high (above 6 lakh) based on annual income in INR. According to statistics of survey 34%, 27% were high income level, 48% and 52% with middle income class and 18%, 21% with low income level from north and south zone respectively. Hence surveyed respondents belong to middle class family with fairly equal low and high income class personals. The histogram plot (Fig. 7 clearly reveals the distribution of the survey and constitute representative sample.

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		

Another important factor that decides perception and attitude on MSWM is level of education attainment. In this survey it was broadly classified into three levels namely no schooling, schooling and college. Here schooling level education refer to 1st standard to 10th standard, while the college level education includes pre-university level, Bachelor’s level and Master’s level. About 43% and 37% of public from north and south zone respectively had college level education, while 41% and 50% attained schooling education in north and south zone respectively. The remaining 16% from north zone and 13% from the south zone had no form of education background during the survey. A histogram plot was developed utilizing literacy data by comparing it with age and gender to understand the nature of sample selected for survey (Fig. 8). It is observed from the figure that most of the individuals interviewed had college and school level education and very few with no educational background.

5.1 Willingness to keep community clean

Often due to lack of funding & manpower for effective SWM the Corporation/Municipal authority anticipates citizens to be involved and act more responsibly towards handling of solid waste at source. But, due to the carelessness of a few citizens in every area, the waste keeps getting accumulated. Hence a periodic clean-up or restoration has to be followed strictly to avoid the nuisance of open dumping. The frequency of collection varies according to the locality, some will have everyday collection wherein others will have once in two days or once in a week. The questionnaire survey suggested a good door to door collection facility prevailed in Mangaluru (Fig. 9). Nearly 85–90% of north zone respondents observed everyday collection system in their locality, but everyday collection in south zone is 60–65% because the frequency of collection for south zone is less (once in two days or once in a week). This has resulted in open illegal garbage dumping across the roads in south zone regions when compared with north zone area. Figure 10 presents frequent open dumping locations in north and south zone respectively.

About 90% of north zone respondents and 75% of south zone respondents knew that burning garbage in open land is illegal and can cause health risk. Meanwhile, 25% and 35% respondents from north and south zone respectively claimed to observe illegal open dumping in their locality. Public discarding garbage next to collection bin is another major problem that causes hygiene and safety problems. During the survey about 41 people from north zone and 30 people from south zone reported health issues because of open dumping and open burning (Fig. 11). This clearly indicates that extra care is to be taken about the people residing near the dumping yard since health issues are most predominant if MSW is not handled properly.

5.2 Lack of accountability

Lack of accountability due to unsupervised officials and community representative leads to unreliable service. It depends on interest of committee members and whether it is elected body or appointed by government itself. Every category of public should be involved while forming a SWM committee. Over and over, the public as well as the employees who work for a private sector handling MSW take things for granted and knowingly tend to commit mistakes frequently. Involving private sector to provide collection facility under a contract basis with local government could reduce the collection cost as well [32]. The better way to solve this is through written document of agreement stating rights, responsibilities and obligation towards SWMS. Monitoring of the functionality of the collection and transportation is very crucial in MSWM system. Below 10% of respondents from south zone had waste collection bins in their locality. So, to avoid illegal dumping more community bins are suitable and easy solution in south zone. Since north zone had door-to-door collection facility the community bins were not of that prominence.

5.3 Willingness to pay

Willingness to pay directly depends on effectiveness of the MSWM system. It mainly indicates the motivation of the stakeholder and the reliability of the service. The tariff and payment system has to be clear and structured to encourage public acceptance. The waste handling tariff has to be decided based on the quantity and quality of the waste generated at the source. Accordingly, the service charges can be specified based on the collection locality. Municipality alone could not be blamed completely for SWMS

since it generally lacks fund because of cost recovery problems. The income of the garbage collectors and handlers may directly dependent on cost recovery or fees collected. Hence less cost recovered could lead to negative consequences thereby decreasing the reliability of the service. When asked about willingness to pay for MSWM 70% from north zone and 50% from south zone respondents were feeble to pay. Other residents refuse to pay additional amount for solid waste handling due to two reasons, i) perception of having paid already through taxes, ii) due to lack of trust and confidence in the service provider. However, in those cases where there is insufficient fund from the authorities, initiatives can be taken to implement a tariff for better SWM. These issues could be solved through direct involvement of public in planning and operational stages of MSWM facilities.

5.4 Awareness

For better SWM system awareness and knowledge on various functional components involved in solid waste management is very essential. In view of this all the stake holders (governance, policy makers and citizens) involved are required to have great sense of responsibility towards SWM. The municipal authority alone cannot be held responsible for implementation of functional SWM facilities. During the interaction with the respondents about 80% of people from both north and south zones expressed that they have knowledge on solid waste management. Over 74% of north zone and 64% of south zone respondents were aware about health effects caused due to improper SWM. Regarding awareness of ill effects due to open burning of solid waste, around 91% in north zone and 78% in south zone knew that open garbage firing is illegal and punishable offence. Segregation of waste at source plays a vital role in SWMS since it is very difficult to separate the mixed waste in the process of treatment. Even though people are aware that segregation at source leads to effective SWM, only 45% from south zone and 64% from north zone involved in segregating waste at source point. About 98% of north zone and 83% of south zone respondents are aware about existing MSW dumping yard. When enquired about the treatment involved after collection of the waste, 81% of north zone and 65% of south zone respondents had knowledge of it. Remaining 25% of public do not have any idea about the treatment of MSW. Nearly 72% from north zone and 67% from south zone are aware of proper practice of waste disposal. Regarding inclusion of environmental awareness in present education system at school level, 98% and 88% from north and south zone respectively are of the opinion that it is very much essential.

5.4.1 Awareness towards 4R's

The respondents expressed that they are aware of 4R (Reduce, Reuse, Recycle and Recover) concept. Nearly 70–80% of both the zones had good understanding of reduce, reuse and recycle, but only 13–15% of public proclaimed the concept of recovery from waste. Regarding reuse when asked for an honest opinion about carrying of reusable bags for shopping, about 59% from north zone and 53% from south zone responded that they carry reusable bags. It is to be noted that people having higher education had knowledge of recovery from waste. In view of this, awareness about recovery should be created among public and incentives can be provided based on their practices of recovery setups. Figure 12 represents

the understanding from the public regarding recovery, recycle, reuse and reduce concepts. Similar pattern of understanding was observed from both the zones of study.

5.5 Willingness to participate in solid waste management initiatives

Almost 90% respondents from north zone and 70% respondents from south zone showed willingness to participate in solid waste management initiatives. Few NGO's and Swatch Bharath initiative by Ramakrishna Missions, Mangaluru involved in collecting, cleaning the solid waste from public places during most of the weekends is observed. This initiative drove public to participate as volunteers in the mission of Clean India and got good appreciation by public in the city. Likewise, occasionally many educational institutes, private organizations involved themselves in Swatch Bharath Mission that assists SWM system in Mangaluru. The impact of these programs helped to maintain cleanliness and improve environmental conditions in few wards of Mangaluru.

5.6 Acceptance for building facilities near their locality

When asked about their opinion on having a recycling unit or incinerator for treating the MSW within 2 km radius of their locality, one fourth of total respondents showed positive response towards incineration plant and around one third of respondents from both the zones accepted to have recycling unit near their locality. It is understood that respondents were not ready to accept any MSW facilities near their stay. The main reason for rejection was fear of having health issues, odour, environmental nuisance and lowering of their property value. It was observed that the youth are objecting such innovative initiatives. This indicates that there is an urgent need for awareness program and environmental education.

5.7 Overall perception of existing SWMS in Mangaluru

The survey data revealed a positive attitude towards existing SWMS in Mangaluru with few suggestions for improvement. This question was categorized into five sections namely extremely satisfied, satisfied, somewhat satisfied, unsatisfied and don't know. North zone respondents appeared to be more satisfied than south zone respondents; it was obvious due to better collection practices in north zone region. Nearly 75% respondents from north zone and 50% respondents from south zone were satisfied with the prevailing SWMS (Fig. 13). Average and below average satisfaction level were more in south zone when compared to north zone. Hence Mangaluru City Corporation has to consider this public opinion earnestly and study the ground reality for improving the MSWM system in south zone localities. About 10% of total respondents from both the zones had no knowledge about the system.

To understand the performance of any sector through most of stake holders the performance indicator can be used. This will provide an outlook of system efficiency, and also reflects indirect factors like financial performances, organization capacity and other factors. Generally, it can be measured either from managers or through citizens perspectives. Table 10 provides the service level benchmark

evaluation of solid waste management system of Mangaluru city. It clearly indicates that there is a need for a more organized, scientific treatment and disposal system for effective SWM.

Table 9
Service level benchmark indicators of SWM system

SI 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	100%	20%
4.	Extent of municipal solid waste recovered/recycled	80%	70%
5.	Extent of Scientific disposal of municipal solid waste	100%	30%
6.	Extent of cost recovery in solid waste management	100%	15%
7.	Efficiency in redressal~ customer complaints	80%	70%
8.	Efficiency in collection of user charges	90%	30%
Source: SLB notifications of Karnataka ULB'S 2011			

5.8 Awareness programs

To reach maximum stakeholders regarding awareness, inclusion of environmental education as an integral part of curriculum both in schools and colleges is essential. Most of the education institutes in Mangaluru have successfully implemented Swatch Bharath Mission that works towards clean India. Some universities have also transformed their work culture to sustainable and greener initiatives, wherein proper planning of solid waste in the campus is practiced [33]. For example, reducing paper consumption by encouraging online practices, recycling and two-way printing etc. Communities should be educated with the importance of waste segregation, methods of segregation at source and its effectiveness in MSWM system. Major issues related to waste management could be resolved easily once the wastes are segregated based on their properties of degradation. Household individuals should be educated through mass media about waste management programs. Booming social media platform can be utilized to share and spread the awareness campaign of MSWM system. This would be most effective and vast spread program since it can reach all the citizens of the country. Elected representatives and environmental officials can lead the awareness campaign by educating citizens on waste management laws and policies. Penalties should be imposed on the individual for violating MSW rules. Encouragement for buy-back center should be escalated. Private bodies who are interested in starting up recycling units should be encouraged and facilitated.

Table 10: 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
		1s in 2 days	23	182	11.22	88.78
		1s 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	53	74.14	25.86
9.	Awareness regarding health issues	152	53	72.68	27.32	
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	95.58	03.42	
		201	4	98.04	01.96	
23.	Do you think environmental education and SWM should be thought at the school level	202	3	95.83	01.47	
24.	Do you know where the waste is treated	188	17	91.70	08.30	
25.	Should municipality charge penalties on open dumping of waste	30	175	14.63	85.37	
26.	Opinion of building incinerator near their locality					
27.	Views regarding having a 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

Table 11: Consolidated South zone questionnaire

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 empty	Everyday	124	81	60.48	39.52
		1s in 2 days	23	182	11.22	88.78
		1s 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	113	44.87	55.13
		VC	29	176	14.14	58.86
		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	32.39
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	32	84.39	15.61
23.	Do you think environmental education and SWM should be thought at the 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 a 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

6. Conclusion And Recommendations

While changes cannot be witnessed overnight, the study revealed the existing status of solid waste management with key fundamental of public perception and attitude. The current status of MSWM system in Mangaluru describes the overview, sources with per capital generation that is observed to be similar with most of other cities across the country. It is obvious that as the city expands and progresses towards technological advancements the rate of solid waste generation also increases. Similar to other

cities even Mangaluru faces technical, organizational and economical challenges for well-organized MSWM system. The successful management of MSW not only reduces the land pollution and health risk but also minimizes the pollution of coastal ecosystem.

The data from in-depth interview and survey results were synthesized along with secondary data to draw a conclusion on existing SWM facilities in Mangaluru. The constructive questionnaire was developed by referring various articles involving subjective questionings on perception, attitude and opinion of the respondents. Good feedback with low-rate of no response was encountered while analyzing subjective questions. The holistic survey outcome indicated satisfactory level of SWM system in north zone of study area wherein it slightly reduced its productivity in south zone region. The goodwill of people to involve themselves in managing the MSW has to be utilized and appreciated.

An immediate measure as of now could be providing provisional community bins at suitable distance with regular collection system. A remarkable change in SWM system could be experienced only if there is systematic segregation of biodegradable and non-degradable material at source. Perhaps, it is long drawn exercise since it directly depends on people's perception and attitude. Failing to segregate at source can lead to environmental and health risk due to inappropriate MSW mixing with hazardous waste. Moreover, it also becomes a tedious task to separate the recyclable material like paper and plastics from soiled organic matter. Subsequently biodegradable matter could be treated with either aerobic composting or anaerobic digestion reducing load to sanitary landfill and solving leachate problem. Furthermore, serious attention has to be given for disposal practice and competence of sanitary landfill handling to ensure cleaner environment. Few key recommendations from survey outcomes are listed below;

1. Introducing structured education policy at different levels
2. Encourage initiatives to provide incentive for recycling practice
3. Public participation from planning stage to be increased
4. Encourage institutions, organizations for volunteer in awareness campaign
5. Compulsory environmental and social impact assessment prior to any implementation of modern treatment facilities
6. Upgrading of MCC environmental policies
7. Organize regular discussion summit atleast once in a year to monitor and gain the feedback from stake holders.

Overall the survey was relatively successful in documenting the public perception and attitude towards solid waste management system in Mangaluru. Correspondingly this methodology could be adopted to study other coastal cities that often have economical constraints. Provided with this outcome the succeeding task of the Mangaluru City Corporation should be to adopt innovative treatment techniques and involve more citizens for SWM initiatives.

Abbreviations

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

NEERI National Environmental Engineering Research Institute

N North

NIMBY Not In My Back Yard

PSP Private Sectors Participation

RM Ramakrishna Mission

SL Sanitary Landfill

SLB Service Level Benchmark

S South

SL Sanitary Landfill

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 Vermi-composting

Declarations

- Ethical Approval and Consent to participate

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

- Consent for publication

We undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

- Competing interests

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

- Authors' contributions: The authors confirm contribution to the paper as follows:

- Study conception and design: Author A, Author B,
- Data collection: Author A, Author B,
- Analysis and Interpretation of results: Author A, Author B,
- Draft manuscript Preparation: Author A,
- Both the authors reviewed the results and approved the final version of the manuscript.

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- Authors' information

• Sanjith S. Anchan (Corresponding Author - sanjithsj@gmail.com)

Ph.D Research Scholar

Department of Chemical Engineering,

National Institute of Technology Karnataka, Surathkal-575025.

11.07.2021

• Dr. Palakshappa K (palakshappa@yahoo.com)

Professor, Department of Civil Engineering, PACE, Mangaluru - 574153.

11.07.2021

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Figures



Figure 1

Mangaluru study area Map

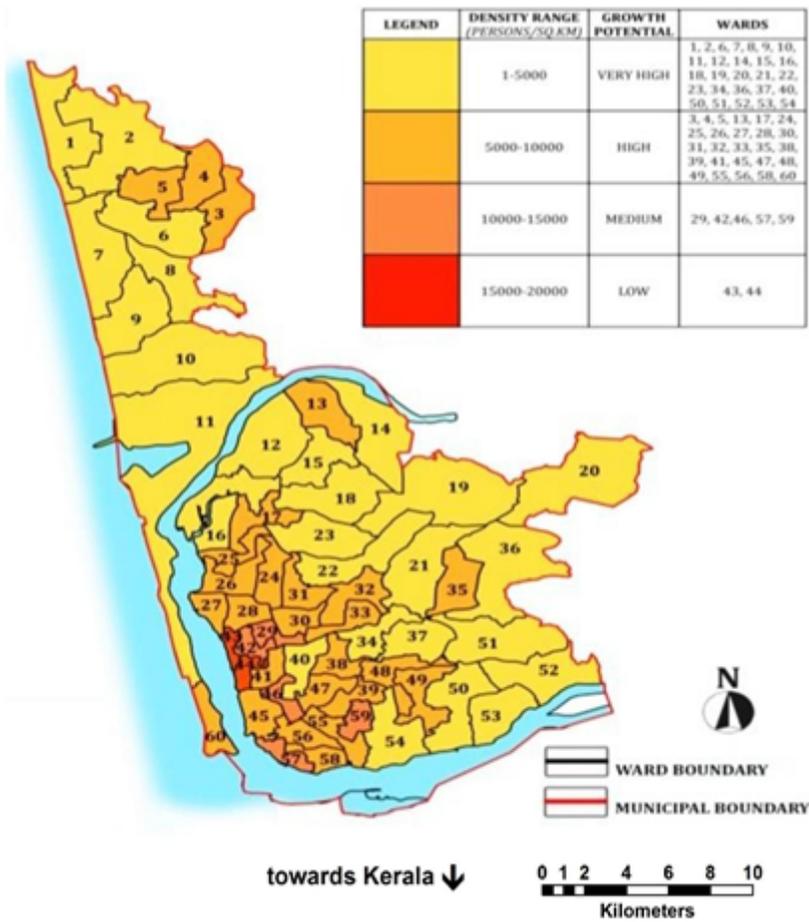


Figure 2

Mangaluru municipality ward map

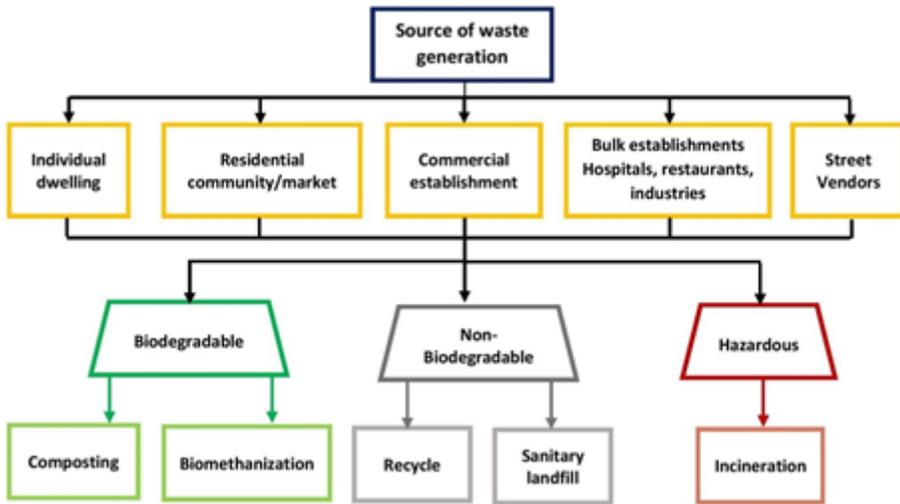


Figure 3

Flow chart representing present Solid Waste Management system in Mangaluru



Figure 4

Treatment site facilities

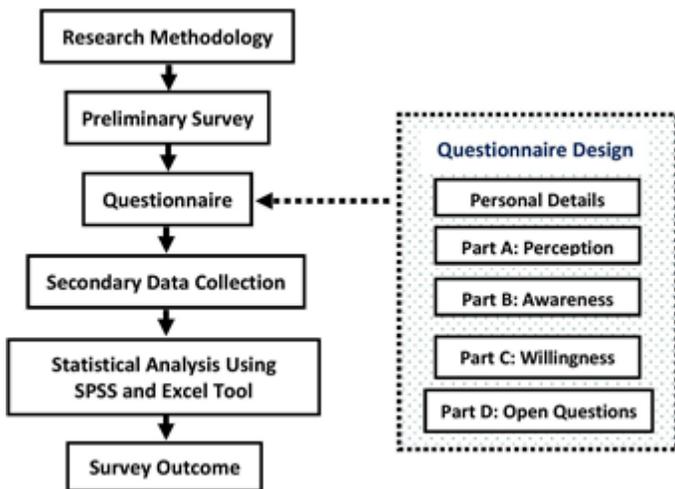


Figure 5

Research methodology flowchart

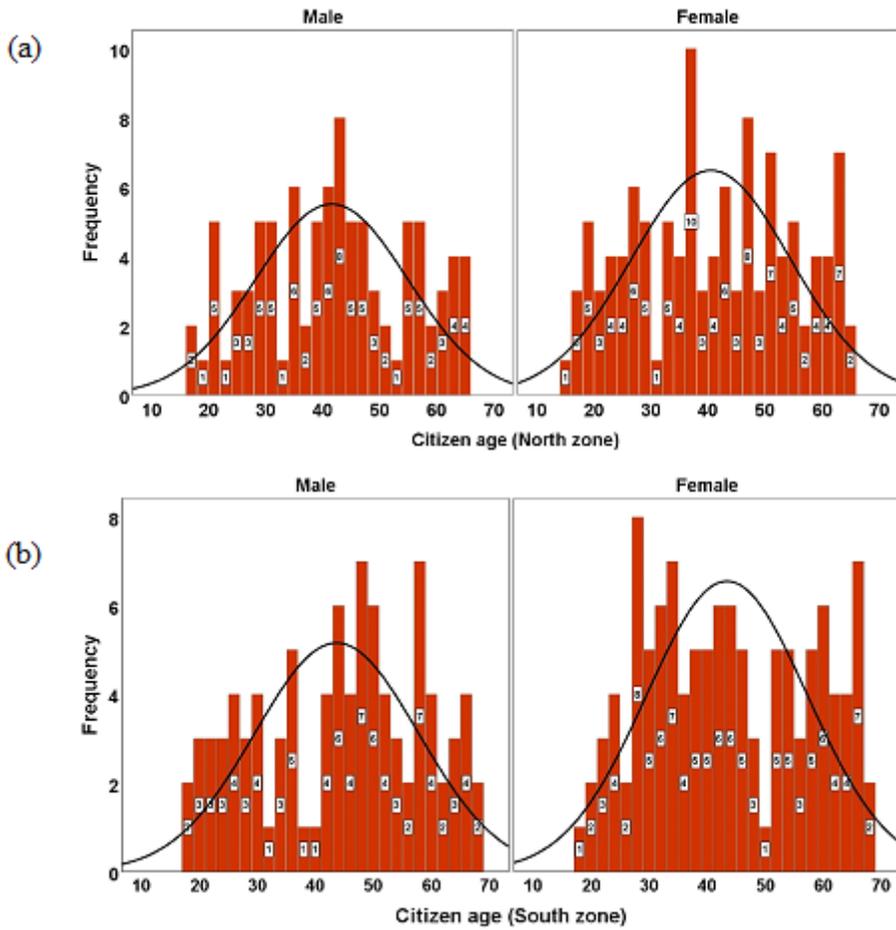


Figure 6

Frequency distribution histogram of citizen age group (North zone & South zone)

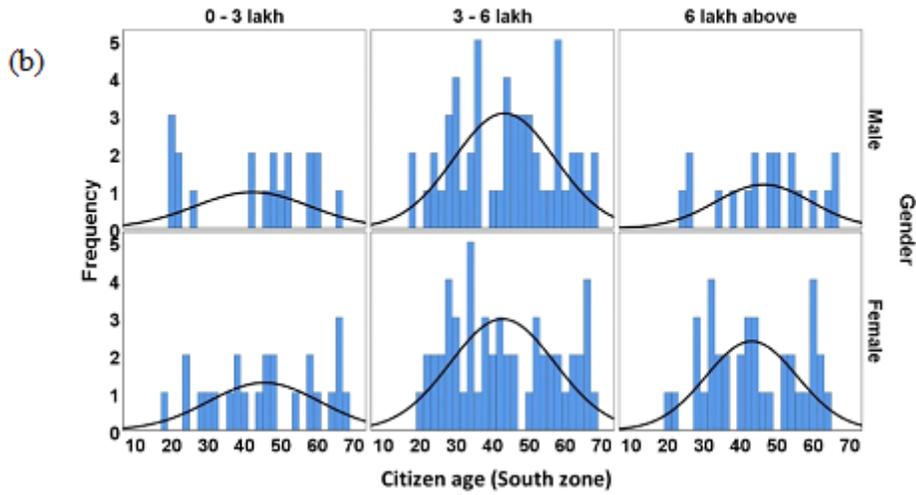
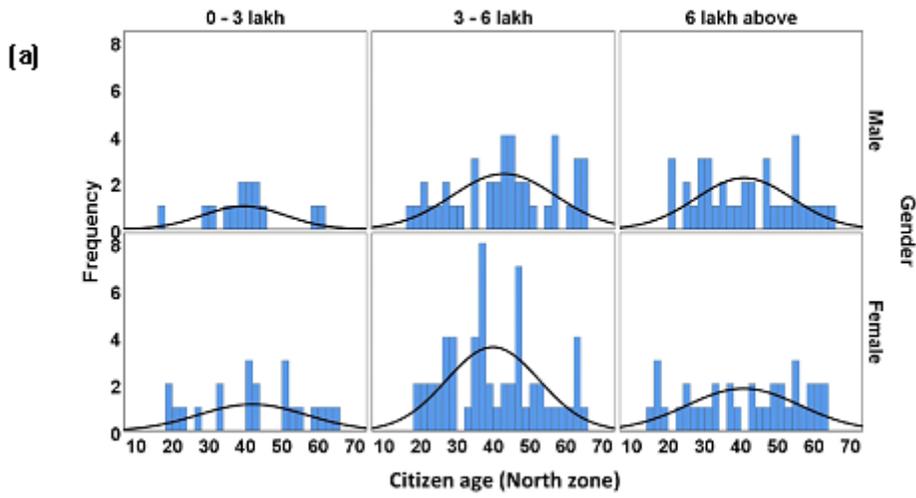


Figure 7

Frequency distribution histogram of citizen income level (North zone & South zone)

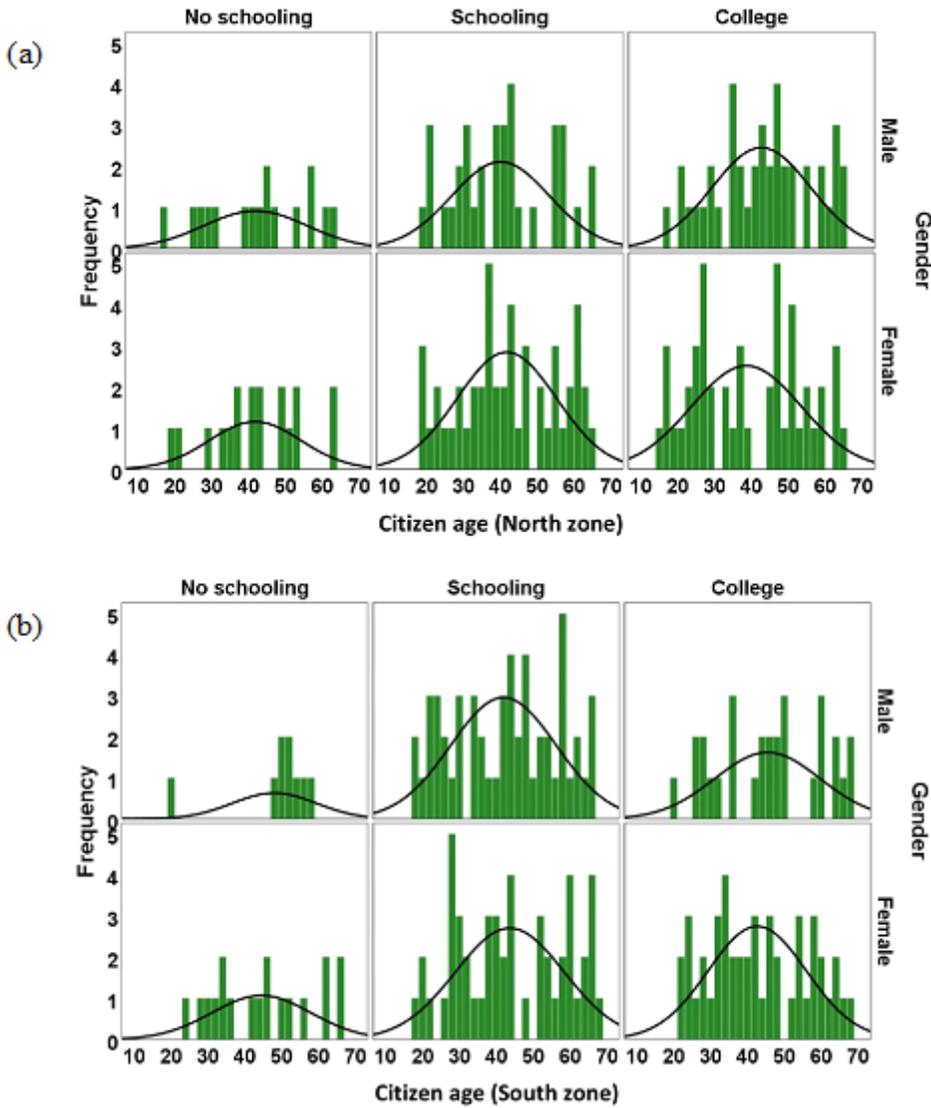


Figure 8

Frequency distribution histogram of citizen literacy rate (North zone & South zone)

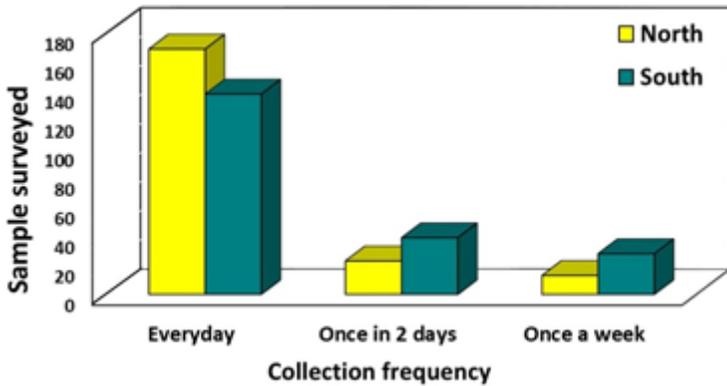


Figure 9

Illegal open dumping locations



Figure 10

Frequency of Municipal Solid Waste collection survey

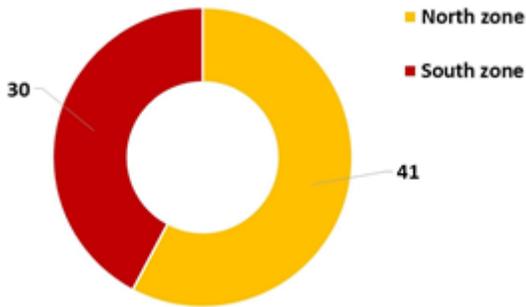


Figure 11

Reported health issues and nuisance due to open dumping

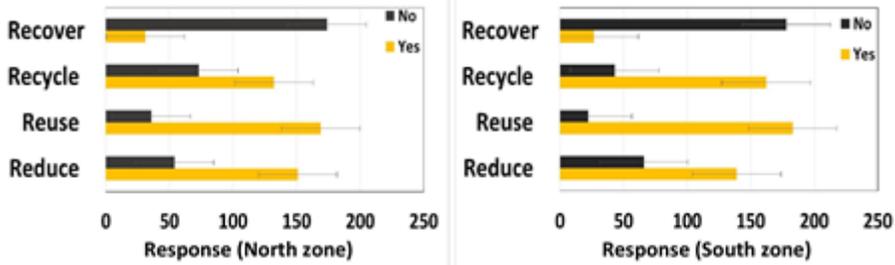


Figure 12

Citizens awareness about 4R concept

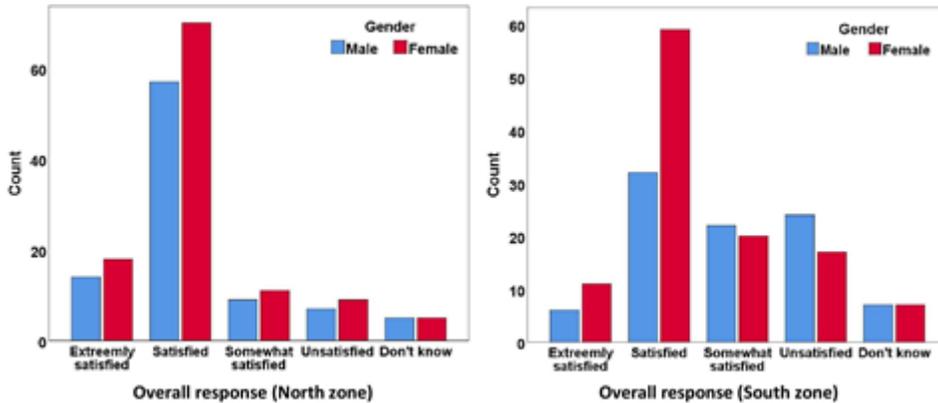


Figure 13

Overall response of citizen over complete Solid Waste Management system in Mangaluru