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RESEARCH ARTICLE

AN ANALYSIS OF SOLID WASTE MANAGEMENT TRANSPORTATION SYSTEM IN BENGALURU CITY

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ABSTRACT

As the population of a city grows, so does the waste that it generates. Along with the industrial and commercial development of a city, waste management systems have to be revised according to the city's needs. Waste management is an important aspect because if not done right, it could lead to contamination and disease. The urban solid waste consists mainly of household waste and commercial waste in either solid or semi-solid form. Waste generated from households is nowadays dominated by plastic and packaging material. Waste from commercial establishments such as restaurants and cafes mainly consist of food waste. Solid waste management is more essential for urban societies as they generate a lot more garbage; the availability of packaged food and other items leads to the accumulation of more trash. Bangalore city generates about 5000 tons of solid waste every day. The Significance of Solid Waste Management has increased because of the increase in population and per-capita waste generation. Transportation is a major component of the Solid waste management process. In order to handle the challenges of transportation of waste from the origin of waste generation to the processing plant and landfills, the researcher makes an attempt to analyze the requirement of vehicles for the waste collection by the transport employees. Requirements needed for the collection of primary and secondary type wastages was calculated with Secondary data collected from BBMP. The interview schedule was used with structured questions to collect the data from employees to identify the satisfaction level and challenges faced by them in their workplace. Suggestions are given in the results and discussion part of this study for the improvement of the transportation system followed in Bengaluru city. This article is published with sponsorship from ICSSR as part of Major Research Project 2018-19 granted to Dr. S. Gopalakrishnan.

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INTRODUCTION

According to the Central Pollution Control Board (CPCB, 2014), Solid Waste Management (SWM) is one of the major problems faced by all the cities in India. Waste quantity is continuously increasing, while the central, state and local authorities are not able to upgrade technologies, manpower, and skills set to handle it (Dhanabalan, 2011). Bangalore generates about 3000 to 3500 tons of Solid Waste daily. The Bruhat Bangalore Mahanagara Palike (BBMP) is carrying out the collection, street sweeping, transportation, processing, and disposal of Municipal Solid Waste (MSW) from generators. BBMP has a system of the door to door collection for collecting the MSW. The MSW collected has to be processed before landfilling.

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BBMP has taken several steps to streamline the MSW management in the city. Solid waste management is the only service that is exclusively a municipal service across India. Often this service is provided by the health department of ULB (Urban Local Body), usually headed by a Health Officer. Presently, several deficiencies persist in the management of solid waste across Indian cities. These are following factors: the absence of segregation and storage of solid waste at source; lack of proper primary collection system from the source of waste generation inadequate system for the transportation of solid waste; and unscientific processing and disposal of waste (Chanakya and Sharatchandra, 2005; Rajamohan and Dhanabalan, 2013). The significance of transportation of waste has increased manifold due to the increase in population, area and per capita waste generation. Transportation operations of Solid Waste involve several steps that are necessary for proper disposal. In Bangalore Municipality transportation of waste, is

done in many ways. It is transferred from source collection done by auto tippers, and then the waste will transfer into compactors at the designated place at the secondary level (Lakshmikantha, 2006). From the transfer point, the wastes are removed by the collection vehicles through-loading operations. This loading is both manuals as well as mechanical, depending on the type of MSW and location. At this point, the wastes are in-transit storage and remain so during transportation operation for a few hours. The wastes are then hauled and ultimately reach the final disposal site on the same day (Rajamohan and Dhanabalan, 2013a). At this site, the wastes are unloaded and collection vehicles return to generation site for refilling. Municipal solid wastes are regularly disposed of in open space dumpsite.

REVIEW OF LITERATURE

The various sources generating organic waste can be broadly categorized into bulk waste generators and individual generators. Individual generators include all individual houses, and bulk waste generators include marriage halls, markets, hotels and restaurants, hostels, apartments, bus stands, railway stations, airports, and temples. The Karnataka state pollution control board has issued circular mandating big educational institutions/big campuses to manage the waste inside their premises and has also directed to establish landfill site in the campus with a design period of 5-10years (Nunan, 2000; Rajabapaiah, 1988; Rajamohan and Dhanabalan, 2014). The Bengaluru Corporation has issued circular mandating bulk waste generators (units producing more than 100kg wet waste per day) to manage the organic waste inside the premises, wherever space constraint does not exist. Otherwise, can handover the organic waste on payment basis to the corporation waste collectors or make their own arrangements to manage wet waste (Ramachandran, 2006; Dhanabalan and Rajamohan, 2014a). In view of the above mandates and voluntary initiatives, some of the hotels are diverting their waste to biogas plants established by private parties outskirts the city, a 5 TPD biogas pilot plant is established by the corporation to manage market waste, a 5 TPD biogas plant is established by a private-government initiative at Yelahanka zone to manage bulk organic waste from hotels, many resident welfare associations have established decentralized composting plants, many apartments have decentralized composting plants and many individual house owners are practicing household waste management by dump earthen pot /manthans and many educational institutions have established decentralized composting plants (Sudhira, 2007; Rajamohan and Dhanabalan, 2013b).

The overall effort in diverting organic waste from reaching the landfill site accounts for just 25-30 TPD. The rest of the waste is reaching waste processing center/landfill sites located outskirts the city. Dry waste comprises the recyclable and non-recyclables dry waste, household and commercial hazardous waste, biomedical waste. Bangalore Corporation has established 15 dry waste collection centers with the objective of collecting the dry waste (both recyclables and non-recyclables) where secondary segregation is done and rejects are sent to the landfill sites (TIDE, 2000; Rajamohan and Dhanabalan, 2014b). Also, there are around 150 informal dry waste collection centers collecting only recyclables having high economic returns. The collective effort by both formal and informal recycling centers is able to divert about 200tons of recyclables reaching the landfill site.

Since, there does not exist any separate collection vehicle, as well as separate collection schedule and segregation of waste at source, is not strictly adhered to by the waste generators, mixed waste consisting of both organic and recyclables, reach landfill/processing centers. In Bengaluru, there are about 30 lakh households, waste collection efficiency projected by the authority is about 80% from 24lakh households waste is collected every day (UNEP, 2002; Rajamohan and Dhanabalan, 2012; Van Bukering, 1994). Let us say, out of 24 lakh households, some 80% of the households handover the organic waste in plastic covers, then it results in about 1,92,000 plastic covers reaching the disposal site along with organic waste; affecting the efficiency of both compost plant and the recycling activity. The dry waste also consists of household hazardous wastes such as toilet cleaners, paint box, tube-lights, CFL bulbs, mosquito coils, cosmetics, razor blade, expired medicines, and medicine bottles, etc. and commercial hazardous waste such as cosmetics from beauty parlors and hair salons, expired medicines from medical facilities. Since these kinds of hazardous waste are collected along with dry waste, poses danger to the waste recyclers.

Since for the collection of municipal hazardous waste, a separate collection system does not exist they reach municipal landfill sites as rejects along with the non-recyclable dry waste. The non-recyclable dry waste consists of styrofoam, rags, thermal coal, soiled paper, already recycled materials, etc. Municipal bio-medical waste comprises of diapers and sanitary napkins from residences, hostels, big shopping malls, etc. there did not exist and does not exist any management system to handle the same. As per the directions from the Corporation in 2012-13, it has to be wrapped in newspaper and should be handed over to the bio-medical waste collector who in turn manages it by incineration (Thirupathi et al. 2018). In the present system of waste collection, only in some apartments, hostels and big shopping malls, it is handed over to the bio-medical waste collector. Since the bio-medical waste collection is on a payment basis, no such agreement exists between the Corporation and the bio-medical waste collector, absolutely there does not exist any control over this in the bio-medical waste collection from individual houses. It reaches the waste processing/landfill sites along with other wastes, obviously contaminating all the other types of wastes.

OBJECTIVES

- To analyze the effectiveness of the transportation system used in solid waste management in Bangalore
- To assess the public's opinion towards the collection of primary and secondary level wastages
- To appraise the workers' opinion towards the facilities provided for the personal safety

METHODOLOGY

The methodology adopted for collecting data with regard to, transport and disposal of municipal solid waste, included a collection of information pertaining to solid waste management (SWM), from published documents, data available with the agencies and through consultations. It was done through primary surveys, especially on the assessment of the physical characteristics of wastes and consultations to understand the felt needs and priorities of the communities and the key stakeholders.

In addition, data was also collected by using observation and interview methods through interactions with the transport employees.

SAMPLING

Sampling considered desirable when the universe happens to be small and a known characteristic of it is to be studied intensively. Convenience sampling is a specific type of non-probability sampling method used to collect the data from transport employees conveniently available to participate in the study. The sample size is 362 as per Rao soft format and the researcher also conducted the survey with 362 respondents. Due to incomplete information in the schedule from 15 respondents, the final data were analyzed based on the remaining 347 respondents' opinions. Table 1 presents the Demographic profile of the respondents.

Demographic profile of the respondents: Table 1 reveals that the demographic profile of the respondents. There are 347 respondents were contacted for this research, of which 217 males and 130 females. 18.43 percent of the respondents were in the age group of 18 to 25, 46.10 percent of the respondents in the age group of 26 to 30, 21.90 percent of the respondents in the age group of 31 to 35 and 13.57 percent of the respondents were in the age group of more than 36. As far as the educational qualification of the respondents is concerned 70 people were illiterate, 127 were studied upto primary school education, and 85 and 65 respondents were studies upto SSLC and HSC respectively. 98 were driver, 187 worked as waste collector and 62 were helpers. 137 were appointed by BBMP and 210 appointed on the contract basis.

Statistical tools: For analyzing the effectiveness of the transportation system utilized for the collection of solid waste the Garret Ranking method has been used. To assess public's opinion towards the collection of primary and secondary level wastages the ANOVA test has been used. To appraise the workers' opinion towards the facilities provided for the personal safety, the weighted average technique has been used.

ANALYSIS AND DISCUSSION

In order to analyze the effectiveness of the transportation system used in solid waste management in Bangalore, there are six variables such as availability of wastage collection vehicles, wastages loading time, manual loading followed, usage of covered vehicles for waste transport, condition of transportation vehicles and transportation time have been identified as research factors and responses were collected on these variables with five point scaling technique. Thus total responses were collected for each variable with six different ranks range from 1 to 6. Table 2 shows the responses received from respondents. Table 2 highlights the factors used to assess the effectiveness of the transportation system used in solid waste management in Bangalore. Based on the ranks given by the respondents, the responses were collected on each rank. Thus, in order to identify effectiveness of the transportation system used in solid waste management researcher has used the Garret ranking.

Transportation system followed in solid waste management and garret value: Table 3 shows the garret scores of each value and it was calculated with the help of garret ranking formula. Based on the garret score values the garret Table has been framed. There are six variables and its scores are multiplied by the respective ranks, in order to record the scores in the Table 4 by using the formula:

Percent position = 100 (Rij – 0.5) Nj
Rij = Rank given for j^{th} variable by j^{th} respondents of variable ranked by the jth respondents.

Nj = Number of variable ranked by j^{th} respondents.

Table 3 shows the Garret scores of the research variables. Based on the ranks given to the variables, the Garret Table value has been ascertained. The Garret Table scores of each factor has been multiplied to record scores in the Table 4 at last by adding each row, the total Garret scores have been obtained.

Transportation system followed in solid waste management – garret rank: In order to assess the effectiveness of the transportation system used in solid waste management in Bangalore, the respondents are requested to express their opinion by giving ranks and it was processed through the garret scores. Table 4 indicates the garret scores of the respective ranks. Table 4 furnishes the details of Garret ranks of each variable. Out of six variables, the highest score has been awarded to Condition of Transportation Vehicles, followed by the Usage of covered vehicles in the second place and Manual loading ranked as third position. Likewise each work has its own weightage and the least score has been awarded to Transportation time. Therefore, it is concluded that the condition of the vehicles are good, however transportation time is improper. Hence necessary actions need to be taken towards regulating the transportation timings.

Public's opinion towards the collection of primary and secondary level wastages: Primary collection is the collection of waste from the point where it is placed by the person or organization that has produced it. These collection points could be located outside each individual household and business, communal containers serving a number of households, or waste skips taking waste from households and businesses in the surrounding area. Depending on the collection vehicle and the distance to the waste treatment/disposal site, the waste at this stage may be taken to the final disposal site or to a transfer station. Secondary collections are where the waste from a number of primary collections is taken from the transfer station to the final disposal site.

Table 9.2 shows some options for secondary waste collection vehicles, but note that some of these are also used for primary collections in certain situations. Likewise BBMP people have collected the primary and secondary level wastages. In order to assess the effectiveness of primary and secondary level waste collection there are six factors have been identified and on which public's opinion have been collected analyzed with the help of ANOVA. The ANOVA is a method which separates the variation ascribable to one set of causes from the variation ascribable to another set of causes. Moreover, ANOVA is a method of splitting the total variation of a data into constituent parts which measures different sources of variations. The total variation is split up into two components such as variation within subgroup of samples and variation between the subgroup of the samples. These variations are tested for their significance by the F-test.

For computing F- value the following formula has been used.

$$F = \frac{\text{Between column variance}}{\text{----------}}$$

Table 1. Demographic Profile of the Respondents

Variables	Items	No. Of respondents	Percentage
Gender	Male	217	62.53
	Female	130	37.47
	Total	347	100.00
Age	18-25	64	18.43
	26-30	160	46.10
	31-35	76	21.90
	>36	47	13.57
	Total	347	100.00
Education	Illiterate	70	20.19
	Primary	127	36.59
	[illegible]	[illegible]	[illegible]
Designation	Driver	98	28.24
	Waste Collector	187	53.89
	Helper	62	17.87
	Total	347	100.00
Employment Type	BBMP Employee	137	39.48
	Contract Employee	210	60.52
	Total	347	100.00

Source: Primary Data

Table 2. transportation system followed in solid waste management – garret ranking

Sl No	Various works	Rank						
		1	2	3	4	5	6	Total
1	Availability of wastage collection Vehicles	37	66	82	69	49	44	347
2	Wastages loading time	24	52	118	42	62	49	347
3	Manual loading followed	77	23	72	92	59	24	347
4	Usage of covered vehicles for waste transport	79	91	20	41	82	34	347
	Total	347	347	347	347	347	347	

Source: Primary Data

Table 3. transportation system followed in solid waste management and garret value

Sl No	Calculation	Calculated value	Garret Table value
1	100(1-0.5)/6 = 50/6	8.33	77
2	100(2-0.5)/6 = 150/6	25.01	63
3	100(3-0.5)/6 =250/6	41.66	54
4	100(4-0.5)/6 = 350/6	58.33	45
5	100(5-0.5)/6 = 450/6	75.01	36
6	100(6-0.5)/6 = 550/6	91.66	23

Source: Primary Data

Table 4. Transportation system followed in solid waste management – garret rank

Sl No	Various works	Rank							
		1	2	3	4	5	6	G Score	G Rank
1	Availability of collection Vehicles	2849	4158	4428	3105	1764	1012	17316	4
2	Wastages loading time	1848	3276	6372	1890	2232	1127	16745	5
3	Manual loading followed	5929	1449	3888	4140	2124	552	18082	3
4	Usage of covered vehicles	6083	5733	1080	1845	2952	782	18475	2
5	Condition of Transportation Vehicles	7469	3591	1998	3825	1044	966	18893	1

Source: Primary Data

Here the null hypothesis is that, there is no significant relationship between the age and the opinion towards the collection of primary and secondary level wastages. Table 5 elucidates the age of the respondents and opinion towards the collection of primary and secondary level wastages. The null hypothesis is rejected for all the activities because the F - value is greater than 0.05 and the P-value are less than 0.05 at 5 per cent significant level. Hence it can be concluded that the age of the respondents influences respondents' opinion towards the collection of primary and secondary level wastages.

Workers' opinion towards the facilities provided for the personal safety: Occupational health concerns emanating from solid waste in the informal enterprises relate to the vectors. During focus group discussions and questionnaire interviews with enterprise operators a number of waste related problems were reported. The problems identified included disease transmitting insects such as flies and cockroaches and increasing populations of rodents and odours. In order to avoid such kind of health related problems there are safety measures have been issued to the workers and there are six types of safety measures such as Precaution measures provided,

Adequacy of Precaution measures, Availability of Gloves facemask, Availability Brooms, Metal Tray & Plate, Medical facilities for health checkup were identified and on these workers opinion were collected. In order to assess workers' opinion towards the safety measures provided, the Likert scaling technique has been used.

Table 5. public's opinion towards the collection of primary and secondary level wastages

SlNo	Information	Particulars	SS	df	MS	F	Sig. Level 0.05	Result
1	Usage of Modern equipments in waste collection	Between Groups	9.595	4	2.399	7.994	.0034	Significant
		Within Groups	102.624	342	.300			
		Total	112.219	346				
2	Effectiveness of Door to door Collection of Wastages	Between Groups	19.926	4	4.981	6.072	.0027	Significant
		Within Groups	280.587	342	.820			
		Total	300.513	346				
3	Relevance of Waste Collection Equipments Used	Between Groups	14.695	4	3.674	5.319	.0013	Significant
		Within Groups	236.221	342	.691			
		Total	250.916	346				
4	Officials visit to look after the quality of work done	Between Groups	34.629	4	8.657	18.85	.002	Significant
		Within Groups	157.008	342	.459	8		
		Total	191.637	346				
5	Adequacy of the number of staffs in waste collection	Between Groups	6.235	4	1.559	3.535	.008	Significant
		Within Groups	150.819	342	.441			
		Total	157.055	346				
6	Supply of equipments for the wastages collection	Between Groups	5.549	4	1.387	3.130	.015	Significant
		Within Groups	151.570	342	.443			
		Total	157.118	346				

Source: Primary Data (ss- Sum of Squares, MS- Mean Square)

Table 6. Workers' opinion towards the facilities provided for the personal safety

Sl No	Particulars	HS	S	No Op	DS	HDS	Likert Value	Total	Average
1	Precaution measures provided	31	73	88	89	66	955	347	2.81
2	Adequacy of Precaution measures	96	81	55	58	57	1142	347	3.39
3	Availability of Gloves facemask	19	53	62	60	153	766	347	2.10
4	Availability Brooms	94	43	67	85	58	1071	347	3.18
5	Metal Tray & Plate	95	44	40	57	111	996	347	2.77
6	Medical facilities for health checkup	22	52	34	62	177	721	347	2.17

Source: Primary Data

Likert scaling technique is one of the techniques used to find out which work site facility has the maximum value. The weightage is given to each column ranging from five to one in order to find out the highest average value.

Weightage value = (HS*5 + S*4 + NO OP*3 + DS*2 + HDS*1)

HS = Highly Satisfied, S = Satisfied, NO OP = No Opinion, DS = Dissatisfied, HDS = Highly Dissatisfied

Considering all safety features provided to the workers, majority of the respondents have positive opinion towards Adequacy of Precaution measures and it is proved through the average Likert value of 3.39, followed by Availability Brooms having high value of 3.18. Likewise the rest of the each factor has different outlook.

Conclusion

Planning the waste management and recycling for all of the rubbish produced in this country is an enormous task which involves both logistical planning and scientific knowledge and understanding in order to balance the impact on the environment and the cost effectiveness of the process. Waste management and recycling companies are also feeling an extra pressure to perform their role in the greenest ways possible. It is important to remember that the UK's resources and landfill sites are limited and this has a major bearing on the kind of activities that are carried out. Waste collection and rubbish disposal play an extremely important role in the global cleanliness and sustainability drive, with people's health and the conservation of resources being the responsibility of every government.

To ease the pressure on government agencies, numerous privately-managed organizations also play a part in these waste management and recycling programs. In many cities it means that local government agencies have been left with the responsibility of overseeing the work done by these privately held organizations. Thousands of years ago humans simply dug a hole and buried their refuse and waste. This was an effective technique for these early people because their population was relatively small and they did not produce waste on the same scale or with the levels of complexity that modern humans do. Burying the rubbish helped to prevent bugs and rodents from becoming a nuisance and spreading diseases. In the modern world burying all of our rubbish is not a sustainable solution. While primitive humans produced very little waste, and that which was produced would biodegrade quickly, modern humans produce much larger amounts of waste, much of which is not biodegradable. Additionally, many types of waste may be damaging to the soil, ground water and surrounding habitat. The most important reason for waste collection is the protection of the environment and the health of the population. Rubbish and waste can cause air and water pollution. Rotting garbage is also known to produce harmful gases that mix with the air and can cause breathing problems in people. By inspecting the vegetation around landfill sites carefully you can determine the damage that can be caused by garbage and waste if left untreated in the open. To address this problem modern waste management professionals place garbage in lined holes and use bacteria to help facilitate its rapid decomposition. Rotting garbage and waste emanates a foul smell that can cause nausea among people who come into contact with it. It can also be a source for waterborne diseases such as cholera and abdominal conditions and discomfort. Since water sources need to be protected the role of waste disposal companies is very important. These organizations should make it a priority to secure their landfill sites so that water bodies are not affected by the garbage and waste collected from homes and commercial establishments.

Waste collection companies also sort the garbage into recyclable columns, as recycling the products that leave our homes is of utmost importance. Recycling not only helps in conserving our natural resources but also reduces the cost of production of many products. Products such as glass, oil, plastic, paper can all be recycled which will ultimately put less pressure on the natural resources used to manufacture these products. Lastly, waste management and recycling collection can help conserve our planet's natural beauty which can be flawed by thoughtless disposal of waste, fly-tipping and senseless littering. Landscapes can be ruined through littering and places of tourist interest can lose their attraction; it is also blight for those who live in areas where waste collection and recycling is not managed effectively and responsibly. Natural beauty is a legacy and a right for future generations and conserving it, as well as our natural resources, for their benefit is our responsibility today. There are many challenges facing the waste management and recycling industry but there is also a lot of excellent work going on to ensure that this is an industry to be proud of and one that will continue to secure effective, sustainable and ecologically sound waste management and recycling for many years to come.

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