Factors Affecting the Generation of Solid Waste: A Review

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Abstract

Solid waste management is considered a serious issue in India. In order to make effectively manage them, it is essential to ensure accurate methods for estimating types of solid waste, its quantities and distribution.

This paper examines different factors that affect solid waste generation in India. The study explores the relationship between income, education, occupation, lifestyle, urbanization, population density, infrastructure, and climate, and their impact on waste generation.

It employs a document survey and analysis of relevant past research studies, reports, and data which focus on factors influencing waste generation.

The conclusions offer ways of developing effective waste management strategies that can reduce the environmental impact of solid waste generation.

Keywords: Solid waste, Management, Sustainable, Socio-Economic, Spatial, Waste quantification.

Introduction:

Waste is considered a major environmental and public health-related issue especially in developing countries (Ziraba, Haregu & Mberu, 2016). The problems are highly related to generation of solid waste because they need to be managed through a system and disposed. Most waste is generated by households. Various studies on the issue of the generation of solid waste have found that they are related to the societal changes, demographic patterns, use of land, social status and wealth levels, locations of residents, and status of the community as well. Many have also described the inter-relationship between household solid waste generation and social-economic factors including its composition and relevance (Beigl, 2004).

In terms of economics, it has been found that agglomeration of household waste depends upon changes in the income levels, and results from refusal of fees for the services, refusal to follow packing and collection, sizes of households, patterns in diversified cultures, and personal attitudes of people.

In this context, this paper examines the factors affecting the generation of household waste. The aim of the paper is to explore the relationship between different factors and their impact on solid waste generation. Its objectives are:

- To identify the socio-economic and spatial factors that affect solid waste generation.
- To identify specific social and spatial factors.
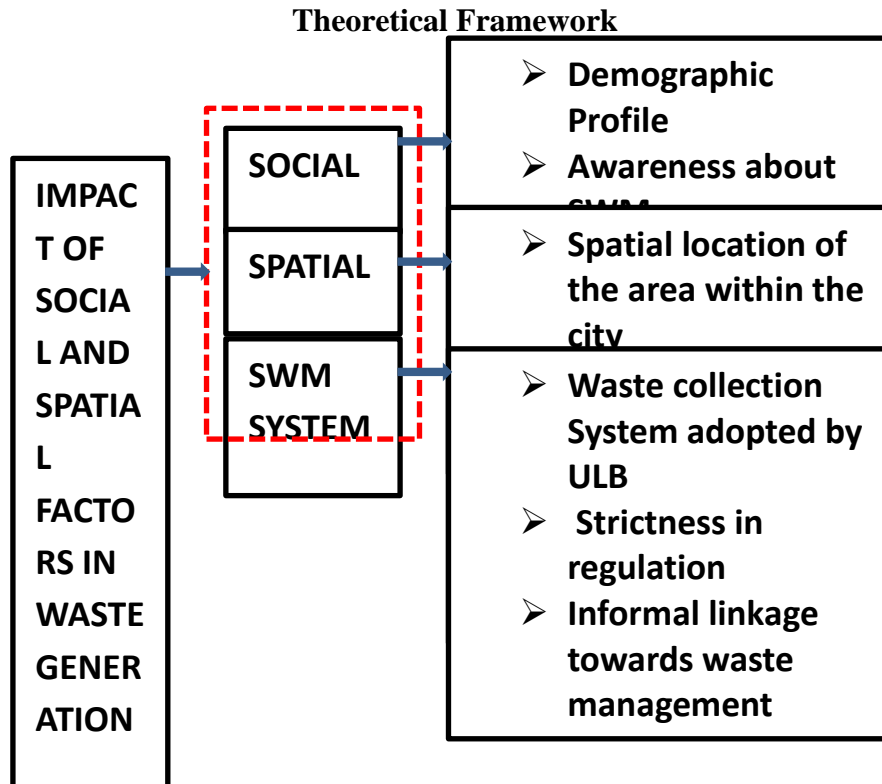- To evaluate the processes suggested by experts.

Theoretical Framework

IMPACT OF SOCIAL AND SPATIAL FACTORS IN WASTE GENERATION	SOCIAL	➢ Demographic Profile ➢ Awareness about SWM
	SPATIAL	➢ Spatial location of the area within the city
	SWM SYSTEM	➢ Waste collection System adopted by ULB ➢ Strictness in regulation ➢ Informal linkage towards waste management

Fig1: The main categories of factors influencing solid waste management
Source: author

The theoretical framework of solid waste management factor identification involves illustrating the interconnected elements that influence effective waste management. Arrows between the elements signify the interconnectedness and mutual influence of these factors.

Waste

Waste refers to any material, substance, or by product that is discarded, no longer wanted, or deemed unusable. There are different types of waste. Solid waste is of different types such as municipal waste, commercial, agricultural waste, medical waste, construction and demolition waste etc.

Municipal Waste

Several academic investigations predict that, if current practices continue, the total global waste produced is expected to reach 46 billion tons by 2050. In contrast, municipal solid waste (MSW) makes up a smaller fraction, fluctuating between 2.3 and 3.1 billion tons (with an average of 2.7 billion tons) in 2019.Municipal waste is the highest in quantities in most cities of the world. Managing them is a very challenging task for the urban planners and decision makers (UNEP, 2015). The United Nations (1992) setting out the agenda 21 concerning the environment and development stresses that sound solid waste management is essential to make safe disposal of waste. It also stresses on reducing waste by maximizing recycling and reusing methods (Gde, dos & Rocha, 2014). To achieve this, it is necessary to know how Municipal waste is generated. It will help provide a direction on the quantity and type of solid waste and its creation enabling capacity building.

Municipal Solid Waste Management in India

Compared to the developed countries, the composition and quantity of solid waste in developing countries show variations. The major portion of waste in India is biodegradables and food waste. In India, there is no effective waste quantification or management system implemented by the municipalities. Proper waste segregation at the source is a critical aspect

of MSW management. Limited facilities and exact quantity of waste for waste processing and recycling is a major problem in most of the cities. Many waste disposal sites are also overloaded (Chatterjee, 2016). It is difficult to make efficient management without having an accurate method that provides a correct estimation of type quantity and distribution of solid waste effectively (Narayana, 2009).

Factors Affecting Waste Generation
Socio economic factors

1. **Income and Its Impact on Waste Generation**

   The income level of individuals and households has been found to have a significant impact on the amount of solid waste generated. Higher income levels are generally associated with increased consumption and therefore, higher waste generation. Studies have shown a positive correlation between income and waste generation, with affluent households producing more waste than low-income households (Beigl, 2004).

2. **Education and Its Impact on Waste Generation**

   Education levels have also been found to influence solid waste generation. Individuals with higher levels of education tend to be more aware of environmental issues and are more likely to engage in sustainable behaviors, such as reducing waste generation. Several studies have shown that education is negatively correlated with waste generation, with individuals with higher education levels generating less waste than those with lower education levels (Khan, 2016).

3. **Occupation and Its Impact on Waste Generation**

   Occupation is another socioeconomic factor that has been found to affect solid waste generation. Individuals in certain occupations, such as healthcare, hospitality, and food service, generate more waste than those in other occupations. However, the relationship between occupation and waste generation is complex and varies depending on the specific industry and job type.

4. **Lifestyle and Its Impact on Waste Generation**

   Lifestyle factors such as diet, shopping habits, and leisure activities can also impact solid waste generation. For example, individuals who consume a lot of packaged and processed foods generate more waste than those who consume fresh and locally sourced food. Similarly, individuals who engage in activities such as shopping for non-essential goods or frequent travel generate more waste than those who prioritize sustainability in their leisure activities (Fan Klemeš & Chew, 2021).

Spatial factors

1. **Land use**

   The use of land and its parameters to create solid waste is attempted for the residential use of land which is not considered only factor but also includes other factors like household size, income that also depend on the typology of housing, area of the floor of Residence and lifestyle only. The area of the plot be an indicator of the number of occupants in a residence. Larger residences may accommodate larger families or multiple households, which can lead to increased waste generation due to higher consumption levels.

2. **Built density and Its Impact on Waste Generation**

   Population density is another spatial factor that affects solid waste generation. Higher population densities generally lead to increased waste generation due to the higher concentration of economic activity and consumption. However, the impact of population density on waste generation varies depending on the specific context, such as the level of infrastructure development and waste management practices (Chithra, 2016).

3. **Building typology**
Quantity and composition of solid waste can be identified though the types of buildings. The previous research considering empirical and geospatial analysis based on building type such as detached & semidetached house, multi storied housing type gave a effective quantification method.

Waste Management Systems
1. **Lack of sufficient infrastructure**
In the past study conducted by different researcher, it was examined that the municipal waste management system in India is highly burdened and could not undertake more responsibilities. There has been an increase in the demand for solid waste management activities in urban as well as rural regions but due to lack of sufficient manpower, the services provided by municipal bodies could not be extended to many regions (Ferronato & Torretta, 2019). There is a lack of sufficient infrastructure like garbage trucks, landfills, and resources to fulfil the increasing demand for solid waste management. In such conditions, people are forced to throw garbage in open places that make the neighbourhoods unhygienic and filthy. It degrades the living conditions of people and the settlements become prone to diseases and pollution (Narayana, 2009).

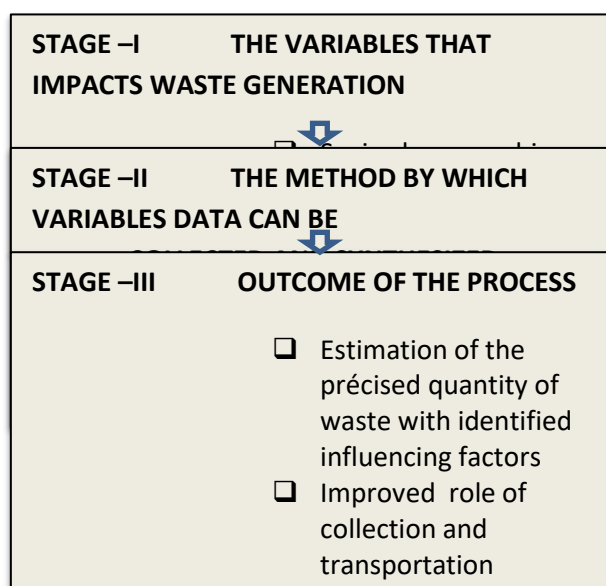2. **Rules and strictness adopted by Urban Local Bodies (ULB)**
Approaches and oversight of waste management systems by the urban local bodies play an important role in managing solid waste. "User fees" and "spot fines" rules newly introduced for littering and segregation should be adopted by ULB for mandatory segregation at household levels and for cleanliness of the surrounding (Abdulredha, et al.2020). Factors such as the role of norms influence the habits which have important roles in adopting recycling behaviour by an individual.

3. **Informal sector**
Inclusion of informal sector plays an important role in waste management due to their contribution in collection process (Gonçalves et al. 2018). Most of the authorities do not formalize their role in Solid waste management (SWM). While the informal sector plays a crucial role in waste management, there are challenges associated with it. Informal waste workers often face poor working conditions, low wages, health risks, and limited access to social protection. Integrating the informal sector into formal waste management systems, providing training, infrastructure, and legal recognition can help address these issues while maximizing the sector's potential for sustainable waste management.

Research Methods
This research employed two research methods. First, it carried out a document survey. It also employed a survey of opinions of experts obtained through interviews.

STAGE –I	THE VARIABLES THAT IMPACTS WASTE GENERATION
STAGE –II	THE METHOD BY WHICH VARIABLES DATA CAN BE
STAGE –III	OUTCOME OF THE PROCESS ❑ Estimation of the précised quantity of waste with identified influencing factors ❑ Improved role of collection and transportation

Fig 2: Methodology flow chart
Source: author

Expert opinion survey

This survey was conducted to gather insights and perspectives from individuals who have specialized knowledge and expertise in a particular field or subject area. These surveys aimed to capture the opinions, judgments, and insights of experts to inform decision-making, policy formulation, or research analysis Observation taken from a group of respondent identified, comprising of urban planners, infrastructure planners, academicians, SWM Consultant Company, ward councillors, supervisors and other stakeholders of SWM who were interviewed through structured questionnaire. The factors which were identified through literature were verifies and rating given in terms of its feasibility of getting data, relevance in SWM system and applicability in other areas. Some of the observations or opinion taken regarding different factors are listed below

Findings

Following documents were surveyed and the factors that have strong influence on waste generation were identified from them.

Table1: Factors influencing solid waste generation
Source: Author

DOCUMENTS SURVEYED	DESCRIPTION	FACTORS	CATAGORY
P. Beigl, 2004, Intharathirat & Salam, 2015	population density, household size, individuals in a dwelling, population age structure, gender, income, ethnicity of the populations	**Demography**	**Social**
Buenrostro, et al., 2001	A particular group of people with same races, religious and origin that may have different culture from other groups of people of a country	**Ethnicity**	
Dyson & Chang, 2005	Social behaviour, belief, traditions of particular group of people	**Culture**	
Triguero et al. (2016) J, et al., 2014	willingness to segregation at household level, cleanliness of the surrounding open space	**Attitude-behaviour relationship**	

Kahn et.al,2016	spatial data/land use map, Nearness to CBD, major markets	Spatial location of the area within the city	**Spatial**
Vetter-Gindele et.al, 2019	built up area, housing type	Housing Typology	
(Chithra, 2016)Chitra,2016	Type of use of land(residential, commercial, institutional and others)	Landuse	
Vetter-Gindele, Braun, Warth, Quynh Bui, & Bachofer, 2019	detached, semi detached, row housing, multi-storey apartment etc	Building Type	
Mukhtar, Williams, & Shaw, 2018	collection coverage, collection system	Waste collection System	**Waste management system**
Jones et al. 2010	efficiency, human resource	Available infrastructure	
Mukhtar, Williams, & Shaw, 2018	strictness, fine charges	regulation	
Mukhtar, Williams, & Shaw, 2018	Segregation process, taxation, campaigns	Waste Management Issues	
Kahn et.al,2016	Frequency and amount of waste collected by informal sector	Informal sector	
Jones et al. 2010	Rewards offered for appropriate or desired actions	Incentives	
Pickerin and Shaw, 2015 Emery et al., 2003	visual condition of neighborhood is affected by improper solid waste dumping	Visual quality	**Environmental**
Siddiqua A,et.al,2022	Air quality of the neighborhood	air quality	
N. Ejaz et.al,2010	Vehicle and pedestrian movement is affected by solid waste	Street Condition	
N. Ejaz et.al,2010	Blockage of drains happen due to dumping of solid waste	Waste water drain condition	

Table 2: Expert's opinion on the factors
Source: Author

Factors	Responses	Inferences
Demographic profile(Age, gender, education, occupation, monthly income, ownership status, duration of stay in that place)		The demographic factors were rated high in terms of feasibility and applicability of the data in different areas.
Attitude towards environmental condition(willingness to segregation at household level, cleanliness of the surrounding open space)		Attitude towards environment condition was found to be one of the important factors for waste management. It was rated high in terms of feasibility, relevance and applicability of the database.
Awareness about SWM (Knowledge ,response ,perception & information on SWM)		Awareness of SWM is also rated high that is people who have awareness tend to generate less waste and also participate in waste segregation .
Housing Typology (Private housing, Government housing, Apartment, Mixed Use(residential/commercial)		As per majority of the expert housing type is very much feasible to get the data.
SWM ISSUES(Segregation process, taxation, campaigns, fine charges)		As per the opinion taken, SWM system by the local authority plays important role in SWM. In terms of feasibility and relevance and applicability it was rated higher score.

Discussion

There were 5 main factors such as demography ,attitude about SWM, awareness about SWM, housing typology and issues which were found significant in determining waste quantity were put for a questionnaire survey from the identifies experts. The aim was to verify those factors in terms of feasibility in collecting data, relevance to the study and applicability in the context of the site of waste generation.

Demographic factors found to be most feasible in collecting data, but rated low in terms of applicability. Attitude towards environmental condition was given highest ranking by the experts in terms of feasibility of data as well as applicability. Awareness of people is rated low in terms of data feasibility and applicability in determining the waste generation.
Housing typology is received low rating opinion by the experts towards feasibility, relevance and applicability of the same. Solid waste management and its related indicators are found higher ranking terms of feasibility and relevance and applicability of the data.

Conclusion

Per capita system which is merely a general calculation without identifying the amount of wet and dry waste of data based on solid waste quantity does not give clear picture of the waste quantity. In most of the urban local bodies, the lack of database on waste production, considering in different influencing factors such as awareness, attitude and other waste management issues is required which can help in proper management of waste.

Solid waste collection and disposal method are dependent on the quantity of different types of wastes. In most of past studies waste quantification using social and spatial parameter are studied in discrete ways but not integrated by which more realistic data of municipal solid waste can be generated. The expert interview tried to identify the importance of those factors considered.

This study can be studied further on other relevant influencing factors, their significance level by statistical analysis and results can be utilized for preparation of predictive model for calculation of accurate waste quantity.

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