

A Systematic Review of Tools and Techniques in Street Cleaning Machinery

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1. Introduction

Roads connect places, resources and people around the world and are the dominant mode of transportation in India. There are majorly 6 categories of roads present in our country out of which 9.27% is occupied by urban roads. Urban roads are maintained by municipal corporations. As per the government estimation, there's at present 65 million tonnes of waste generated yearly in the country out of which 62 million tonnes of it are Municipal Solid Waste.

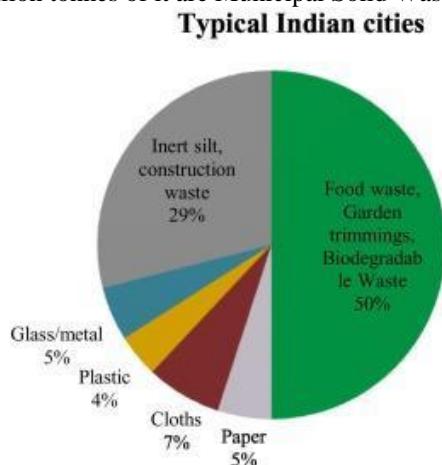


Figure 1: Types of solid waste generated in typical Indian cities

Solid Waste management (SWM) involves collection, transportation, deposit and treatment of wastes making street cleaning an integral part of SWM. These wastes are cleaned and collected using various street cleaning techniques. Even with intensive cleaning techniques and frequencies, the roads are still not clean and we can still visibly see littering and garbage everywhere. To deal with this issue, the central government of India came up with the Swachh Bharat Mission in 2014 to achieve universal cleanliness and sanitation covering all divisions of Indian roads from villages, towns and municipalities. A part of it is making people aware of the importance of cleanliness, hygiene and health, and providing necessary sanitation facilities including solid waste disposal systems. With fewer and fewer people interested in doing lowly paid jobs such as street sweeper, the civic authorities have to depend on machines for cleaning the streets to meet the sanitary needs of the population as cleanliness also contributes to greater general public health.



Figure 2: i. ii- Manual sweepers sweeping roads iii- Swachh Bharat Mission

2. Need of the study

Even with extensive human labor and infrastructure, Indian roads are still unclean. So, it is necessary to review the existing road cleaning system to find out the gaps that are existing in it in order to make the outlook of Indian roads cleaner. On the global picture, the UN's global goals for sustainability include Industry, innovation and infrastructure making it necessary to look into the existing machinery to see for possible innovations and adoptions possible.

3. Aim and Objectives

The primary aim of this study is to know about the existing street cleaning machinery and suggest a better solution with a better understanding of the current waste generation scenario. This would give the knowledge about the infrastructure being used, their efficiency and their downsides to give insights into what can be done in order to achieve better and effective cleaning. Along with it, the aim gives a direction in which the study can be taken further and gives insight into problems that are not thought of when considering the cleaning of streets.

The objectives in conjunction with the aim are identified as follows:

- Understanding the waste on the streets
- Studying waste collection tools, techniques and equipment used to clean the streets
- Reviewing their technical and non-technical constraints
- Evaluating the information collected to see the addressable gaps
- Suggesting a conceptual intervention that can be done that covers the nuances of all the techniques

4. Methodology

In order to carry on with the aim, it is important to narrow down the study to do a plausible field study. For this, I decided to conduct study in the city of Ahmedabad by consulting the city's municipality to carry out the research.

The study will be done in four phases:

The first phase involves studying the general streets and categorizing the type of wastes being generated and ending up on the streets by one means or the other. The main aim of this phase is to understand the waste on the streets.

The second phase involves going to the identified municipal ward and doing an on-field survey to gather information about the methods of cleaning and machines used for street cleaning in that ward, frequency of cleaning and other technical data that is required for the study.

The third phase would be doing data sorting and analysis of the information gathered from the field into various useful categories for better understanding of the entire cleaning scenario. This enables to get an insight on the useful and non-useful aspects of each of the cleaning techniques according to the waste majorly being generated.

The fourth phase is suggesting a plausible intervention that could address all the gaps present without eliminating the scope of employment, sustainability and constraining factors like cost, maintenance etc., that are important in the long term.

5. Understanding the Waste on Streets

To carry out this phase, a general observation of the streets has been carried out. This helped in identifying the following:

The waste on streets can be mainly categorized into three categories:

- 1) Natural waste
- 2) User waste
- 3) Animal waste

1) Natural waste:

This category of waste is eponymous. It involves natural wastes that are generated on the streets such as leaves, grass, small plants, flowers, seeds etc. This type of waste is important for ecological purposes and is to be considered the default kind of waste. This waste is unavoidable and has to be dealt with by default.

2) User waste:

This is the most persistent waste that is observed on the streets. It is generated by human means. It involves wastes generated from general human activities such as littering on streets, shop wastes, garbage disposal on streets, human spits, cups, cigar butts etc., This waste is controllable and avoidable with efficient measures and needs to be eliminated to maximum extent for zero waste generation.

3) Animal waste:

With our country having domestic cattle roaming on roads alongside many other street animals such as dogs and birds, a small percentage of waste that is generated on streets comes from animals and this comes under the category of animal waste. Animal wastes mainly include animal dung, animal urine, dead animal carcasses, bird droppings and feathers etc., Animal waste is considered similar to natural waste and it is important for ecological balance and cannot be avoided.

Apart from these wastes, the city of Ahmedabad in particular deals with a major geographical hassle of having dry and dusty weather. Besides its topography, Ahmedabad also has many industries that contribute to dust pollen of the city alongside its vehicle traffic and biomass burning. All these factors make Ahmedabad a dusty city and dust has also to be considered as a minor contributor to reduced cleanliness.

6. Current Cleaning Scenario

After observing the waste on streets, the next phase in the research is to look into the current cleaning scenario and see the working and the infrastructure used. For this purpose, the research is narrowed down to a single ward in Ahmedabad municipality to study the techniques used there as an integral part of the whole city's cleaning system.

Under Ahmedabad municipality there are a total of 48 wards subdivided into numerous zones for easy administration. Each ward in the municipality employs two distinct types of cleaning techniques they are:

- 1) Manual cleaning
- 2) Machinery cleaning

1) Manual cleaning:

AMC sources most of its street cleaning requirements through manual sweepers only. It employs a total of 1500 manual sweepers throughout the 48 wards present in the municipal corporation. The Chandlodia ward where the research was conducted employs 224 manual sweeping labor.



Figure 3: Manual sweeping being done on various roads in the ward

Manual sweeping is done twice a day in all of the wards during the timings 6:30am-11:30 am and 7:00 pm-1:30 am.

Manual sweepers are employed in all types of roads despite the size because of having no major constraint such as size or accessibility as can be observed in the sweeping machines. The efficiency of manual sweeping is mainly dependent on the age of the sweepers and the age of the broom and the ergonomics of the broom.

The sweepers in AMC use only one main type of broom for sweeping the roads which looks like this:



Figure 4: Brooms used for manual sweeping

“The broomsticks used by street sweepers are not appropriate based on anthropometric aspects, with a potency to induce inconvenience among them. Working with equipment that is not ergonomic, in addition to non-physiological work posture and can cause fatigue, musculoskeletal disorders, and increased workload” [1]

This type of broom is not ergonomic as it is not designed to provide comfort and does not consider anthropometry of the end user. Additionally, the workers work for more than half of the day sweeping the streets with these unergonomic brooms in inhumane conditions of scorching sunlight, dust and dirty places, harsh weather and road traffic too.

There are a lot of health implications that can result from these conditions. “In countries like India and Nigeria, street sweepers often use only short-handled brooms and take no precautionary measures, such as wearing face masks or sprinkling water on the street before sweeping, to minimize dust exposure” [1]. The highest number of street cleaning workers faces musculoskeletal and muscular problems due to long term work involved in the profession. Along with it, respiratory problems are observed in these workers from the everyday exposure to dust, smoke and soot on the roads. All these problems are usually overlooked and the street cleaners have to work for very minimal wages with no real health support provided for them.

This has led to a decrease in street cleaner numbers in recent years along with increased urban population and traffic which led the government to invest in machinery for sweeping the streets.

2) Machinery cleaning:

Upon conducting study for machines being used in the Chandlodia ward, it was observed that the AMC uses two types of street cleaning machinery.

They are:

- 1) JCB-Bobcat Sweeper
- 2) TPS Road Sweeper

JCB-Bobcat Sweeper: This machine is majorly being used to clean narrow roads in the municipality. It collects dust

with the help of a long cylindrical brush and a dust collector that is placed beside the cylindrical brush.



Figure 5: JCB Bobcat Sweeper (i,ii)

The bobcat sweeper is operated by a single person and is usually operated at a speed of 15 kms in order to collect the dust present on the road. In order for it to facilitate this function it has 1.525 meters of sweeping area and an overall width of 1.89 meters. Its brush is a combination of steel and polypropylene.

landfill or a dust collecting van. The vehicle runs on diesel and has a capacity of 460 liters/0.46 Cubic Meters.



Figure 6: Brush of JCB sweeper

The sweeper is operated once per day frequency right after the manual sweeping is done and usually gets emptied into a



Figure 7: JCB bobcat emptying into collecting van

TPS Road Sweeper:

The TPS machine is majorly being used to clean wider roads within the municipality primarily focusing on highway roads under the municipal ward. It collects dust and bits of litter. In order for the machine to do this, it is equipped with two round brushes that are present under the body of the vehicle along its edges. The brushes brush the dust and litter and make it twirl while there is a vacuum present right behind the brushes that sucks in this dust that has been twirled into the air by the brushes.



Figure: 8 TPS Sweeper

The TPS sweeper is operated by two people, a driver and an assistant. It is operated at a speed of 5-10 km/s in order for it to operate at maximum efficiency. This machine comes with a meter of sweeping area and an overall width of 1.89 meter. TPS also comes with a brush that is a combination of steel and polypropylene.

The sweeper is operated once per day frequency also after the manual sweeping is done. The vehicle runs on diesel and has a capacity of 3000 liters. The peculiar usage of this machine is that it is only used to clean along the edges of the highway and cannot be used for cleaning the center portions of the road as its operating method doesn't facilitate this.

7. Observations

From the above data, the main differences within the cleaning techniques have been observed as:

i) Manual Sweeping: When it comes to manual sweeping, the main benefits observed are its reachability, which is being able to clean any kind of road without any constraints of size and condition, its affordability as the labor cost for sweeping is very minimal compared to machinery purchase and maintenance. Alongside its advantages, there are a few nuances present in manual sweeping. The main nuance is the working conditions of manual sweeping. The sweepers need to work in all kinds of weather for long durations and sweep all the roads assigned to them in order to get their wages properly. Secondly, the equipment used by the manual labor

is mainly brooms with long sticks which are not ergonomic at all. They are not suitable for sweepers of all ages and the handles are not designed in a way that makes sweeping efficient and convenient for the sweepers. This makes the manual sweeping inhumane as the wages given are very minimal. Additionally, the sweepers have to work no matter the weather conditions for more than 5 hours of day continuously sweeping the roads allocated to them.

ii) Bobcat Sweeper: The bobcat sweeper mainly comes with the benefits of being smaller in size and thus used to clean narrow roads as it is just 3 ft in width. The other advantage of this sweeper is that even though it is just 3 ft, it has a long cylindrical brush that covers this entire vehicle width which sweeps the dust into the dust collecting pan present on the vehicle. Another advantage of this sweeper is that its attachments are removable, making it multipurpose for usage. The main disadvantages observed in the bobcat sweeper are that it doesn't come with a vacuum making it less clean and efficient than TPS, it also goes to maintenance more frequently and it runs on diesel which is also not sustainable.

iii) TPS Sweeper: The TPS sweeper comes with only one big advantage of cleaning wider roads easily. It comes with a range of different disadvantages of not being able to suck litter efficiently, leaving behind gravel and big chunks of garbage, being unable to clean flat surfaces other than dust in corners. It, also like the other sweeper, runs on diesel and also at very slow speeds of 5-10kmph which can be a major inconvenience on frequently used roads.

S. No	Instance	Benefits	Reason	Drawbacks	Reason
1	Manual Sweeping	+Can reach more places +Cheap Labor	-As it is human being that works, the access to roads is more despite size of road -Wage for sweepers is very minimal compared to cost of machines and their maintenance	-Inhumane -Unergonomic equipment -Less speed-time efficient	-Working Conditions are very poor -The brooms used are not at all ergonomic -Manual sweeping takes more time and is done at slower rate in comparison to machines
2	Bobcat Sweeper	+Compact +Cleans wider area	-Just 3 feet wide vehicle -bobcat sweeper has more sweeping area than TPS	-Can't clean garbage -goes to maintenance very often -can't vacuum -Fossil fuel usage	-Designed to only clean dust -From field research it was observed that the machine goes to maintenance very often -it only sweeps dust off the road and lacks vacuum -Runs on diesel making it non sustainable
3	TPS Sweeper	+Useful for wider roads	-Size of the machine benefits in cleaning wider roads such as highways	-Can clean only corner dust -Can't suck heavy stuff such as gravel -Fossil Fuel usage	-The design constraint of the machine allows it to only clean corners -The vacuum is not powerful to suck gravel and litter bits -Runs on diesel-non-sustainable

8. Solution

From the above observations it can be interpreted that the sweeping machines are confined to a lot of factors as compared to manual sweeping which makes manual sweeping more effective because of the accessibility it comes with when reaching to more roads. But machinery provides the factor of speed over manual sweeping which can make the working time less which can be advantageous as roads need to be continuously used by people. Apart from that, sustainability and overall costs can also be considered as advantageous when it comes to manual sweeping.

This takes us into the sector of semi-manual machinery as a consideration. The solutions that can be given to this problem can be multifold based on the main focus of concern. The most advantageous solution would be the one which attracts employment in the manual sweeping scenario and brings in the benefit of efficiency a machine can give instead of traditional broom sticks. Keeping this in mind, a machine that addresses the user waste of Ahmedabad by having a good

suction vacuum but which is semi-manual operated can be considered as the best solution as it does not eliminate the employment rate and also increases the effective cleanliness.

Semi-manual machines not only increase the labor productivity but also make the sweeping process much more flexible. Also, once a big machine such as TPS is bought, it cannot be improvised and needs to be used with all its disadvantages.

A good example of a semi-manual machine that can be considered is a grass cutting machine. There are also many existing semi-manual sweeping machines that should be employed instead of using sweeping brooms which became orthodox and disadvantageous in more ways than one. One such example is the i-cleanX machine being produced by Triangle Innovations. The machine is used in several wards of the Bangalore Municipality and uses green technology instead of fossil fuels. The machine is designed in such a way that manual intervention is necessary only to push the cart.



Figure 9: iclean X- A manually operated machine being used to sweep roads

Municipalities across the country can adopt this machine as its purchase cost is less, does not require fuel for running the

machine and also does not remove employment for manual labor while reducing their physical burden. In a developing

country like India, where the population is high and impacts many socio-economic factors such as employment, cleanliness and urbanization etc., it is important to innovate and spread useful innovations that can benefit the society.

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