

# Solid Waste Management: Mapping of solid waste in selected Delhi schools

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**Abstract :** Efficient and effective handling of solid waste in educational institutions starts with determining its composition and methods adopted for disposal. Mapping of solid waste was carried out in four stages – (1) Nature of solid waste generated, (2) segregation of solid waste, (3) management of solid waste; and (4) quantum of waste disposed. The waste generated was categorized under 8 major heads (waste paper, plastic, electronics, furniture, garden, food, textiles and other wastes) and sub-heads to understand the waste stream from generation to final treatment and disposal. Results revealed that most of the waste generated in school was gathered at the main collection point of the school without segregation. Furniture and garden waste were the only two categories sorted/ segregated. More than half of the waste produced in selected schools was regularly discarded (51.60%), however, data also revealed that 15.17% of this waste was organic in nature which has the potential to be recycled to reduce the overall impact on the environment. In the light of the results obtained, it is essential to understand the need for incorporating corrective measures aimed at improving solid waste treatment and increasing awareness among school children.

**Intex Terms -** Environment Education, solid waste management, quantum of waste, mapping of solid waste, environment conservation, Delhi schools.

## I. INTRODUCTION

India is the seventh largest country in the world with second largest human resource [1]. A recent report released by NASA (National Aeronautics and Space Administration) revealed that India has played a significant role in greening the planet despite their contribution towards increasing pollutants and green house gases [2]. However, unplanned urbanization, Rapid growth of industrial sector, growing population, rising migration and inefficient actions of the government authorities have been found to be the prime reasons for degraded and unhealthy ecological conditions. Instead of regulating and protecting surrounding, it has given rise to many environmental problems leading to degradation of quality of life [3]. Air, water, soil, slums and sewage are some problems that are creating health issues for many people living in the urban cities.

Efficient disposal of solid waste is another pressing issue concerning countries around the world. Management of solid waste can play a vital role in protecting the ecosystem through creating environment consciousness among masses [4]. Studies suggest that education can be used as a means of integrating SDG (Sustainable Development Goals) with social ethics to achieve sustainable development and environment conservation. Educators around the world have acknowledged and accepted the potential of environment education to sensitize corrective environmental practices among people [5].

Like all other entities, schools also have environmental carbon footprint. They generate daily solid waste, use energy for lighting, cooling and heating; and chemicals for cleaning which in turn has an impact on the environment. But, on the other hand they also play an important role in environment protection by helping students develop conscious behaviour and change attitude towards environment, protecting it for the present and future generations [6].

**Delhi Education System:** According to *Delhi Population 2011-18 Census*, the projected population of the city was estimated at 1.90 Crore (19 Million) in 2018 [7]. Data from Economic Survey of Delhi (2018-19) revealed that there were 5760 educational institutions in the city run by various managements like private sector, local bodies, state government and central government [8].

Table 1: Delhi Education system

	<u>2010-11</u>	<u>2014-15</u>	<u>2016-17</u>	<u>2018-19</u>
Total No. of School	5043	5798	5772	5760
Total No. of Sr. Sec. Schools	1392	1674	2104	2110
Total no. of Students Enrolled	37.38 Lakh	44.13 Lakh	44.43 Lakh	43.93 Lakh

Over the last ten years, number of schools and the total number of enrolments in city schools has increased considerably (Table 1). The statistics depicted in the table 1 suggest that more than 20% (23.12%) of the city's population was in the schools in the year 2018-19. The future lies in the hands of these '**young change makers**' who can be taught about environment and the urgent need for its conservation. Various studies over the years also suggest that is easy to mould children as they have the ability to retain knowledge, create awareness among societies and promote through their practices.

The success of an efficient municipal solid waste management system does not only depend on the availability of resources but also designing a system to gather reliable data [9]. Schools can carry out solid waste handling and treatment when the composition is known to them. Waste segregation through placement of multiple dustbins and sorting of waste can help in determining the recycling potential of the educational institutions.

Students spend considerable time of their day in schools and thus, they have a significant role to play towards the overall solid waste generated on the campus [10]. Improvements in the system can be achieved through the principles of prevention, responsibility, cooperation and team work, transparency and economic feasibility which includes all stakeholders [11].

The present research was an attempt to study management of municipal solid waste in selected educational institutions in Delhi. The main purpose of this paper is to map solid waste generated in Delhi schools to understand its handling, treatment and disposal.

## II. Methodology

The study was conducted in NCT (National Capital territory) of Delhi where 26 schools formed part of the study from the 9 zones of the city, i.e. North, East, West, South, North-East, North-West, South-West, Central and New Delhi.

Sample included students, teacher coordinators and waste collecting staff to obtain information about the composition and recycling potential of solid waste generated in Schools. Secondary data was gathered to form a comprehensive list of different categories of solid waste generated in schools. Semi-structured interview schedule along with transect walks and observation were included to obtain relevant data. The data gathered was utilized to sort waste into eight main categories and various sub-categories for ease of assessment.

## III. Results and Discussion / Findings

Schools generate tonnes of solid waste on a daily basis – biodegradable (like paper, food waste and fruit peels) and non-biodegradable waste (like crafts paper, plastic computers and electronics). Efficient handling of solid waste generated in schools starts with determining its nature and frequency. Mapping of solid waste covered the flow of waste from the source of generation to the final stage of its disposal. The data also helped in obtaining comprehensive information about different streams of solid waste and understand the existing system of solid waste management - collection, segregating and treatment (reuse, recycle and landfill) in schools.

Mapping of solid waste in schools was conducted in four parts –

- I. Nature of solid waste generated
- II. Segregation of solid waste generated
- III. Management of solid waste generated
- IV. Quantum of solid waste

The results of mapping are discussed in the following sections.

### A. Nature of solid waste generated in Schools

Preliminary investigation of the research in revealed that composition of solid waste ranged from fabric to paper to food to electronic goods. They were classified into the following 8 categories and sub-categories as seen in the Table 2 thus indicating the enormous amount of solid waste generated in the schools.

**Table 2:** Nature of solid waste generated in schools

	CATEGORY OF SOLID WASTE	SUB-CATEGORIES
1	Waste paper and products	Waste paper Printed paper Newspaper Cardboard and cardboard boxes Old books Tetrapak
2	Electronic products	<b>Electronic equipment –</b> Computer monitor Computer accessories (like wires, CUP and mouse) Smart class boards Projector screen and monitor, printer and cartridge Mobile phones and landlines CD / Hard drive / Pen drive / DVD  Large electric appliances like Fridge, oven, microwave, freezer, coffee machine, cooler, air-conditioner, washing machine, etc. <b>Batteries &amp; generators</b> Generator and its parts Inverter batteries <b>Lighting system</b> Florescent tubes Bulbs and other lighting equipment Old fans
3	Plastic waste	Plastic bottles · Plastic wrappers · Plastic tubs and containers
4	Furniture products	· Classroom Desks and chair · Cupboards and Almirah · Above the Counter storage · Below the Counter storage
5	Garden waste	· Garden equipment · Dead plants/ dried leaves/ twigs/ etc. · Weeds
6	Textile waste	· Towels · Sheets and covers · Aprons, etc
7	Food waste	· Left over food from lunch boxes · Left over food from canteen · Fruits and fruit peels
8	Other waste	<b>Metal waste</b> · Aluminium foil · Old metal tubs and container <b>Glass waste</b> · Glass bottles, beakers and test tubes

### B. Segregation of solid waste generated in schools

Study revealed that most of the schools followed a basic procedure for segregating waste. The waste was collected from different points of generation (like classroom, canteen, administrative block and garden) and taken to the main collection point identified within the school premises (Table 3). Main collection points were generally found to be located behind the main building for the purpose keeping it away from students, parents and visitors or close to composting pits for ease of management.

**Table 3:** Sorting of solid waste after collection

	Category of solid waste	Source of Generation	MAIN COLLECTION POINT IN SCHOOL For sorting of solid waste	Collection points after sorting
1	Paper waste	Classrooms, canteen & Administrative Block		Main office / collection room Piles in yard with other waste
2	Electronic Products	Classrooms, Laboratories & Administrative Block		E-waste bins or main office Piles in yard with other waste
3	Plastic waste	Classrooms & canteen		Main office / collection room Piles in yard with other waste
4	Furniture Products	School campus		Piles in yard with other waste
5	Garden waste	Gardens		Collected in plies in yard
6	Textile waste	Classrooms & laboratories		Main office for donation Piles in yard with other waste
7	Food waste	Classrooms & canteen		Main office / collection room Piles in yard with other waste
8	Other waste (metal and glass)	Classrooms & canteen		Main office / collection Piles in yard with other waste

Among the various categories of waste generated, student classrooms were found to be generating a wide variety of solid wastes ranging from waste paper, electronics and plastic to textiles and food waste. Garden and furniture waste were the only two categories distinctive from the rest of the waste. While furniture waste was generated rarely as it was an expensive product which could be reused again, garden waste was usually collected from the point of generation itself without any need for segregation.

All the waste generated from different areas of the school was collected at a common collection point on campus and sorted, to be sent to assigned locations for its management. The table indicates that the selected schools were sorting waste both for further processing as well as disposal to the dumping sites.

### C. Management of solid waste

Management of solid waste included categorization of waste into— **Reuse / Recycle / Landfill** to denote their end use or disposal. Application of reuse and recycling of solid waste adopted by schools is discussed in the following section (Table 4).

#### a. Paper waste and products

Paper waste and its products were the largest category of waste produced. The results of the survey revealed that more than 75% of schools were providing their paper waste (classroom paper, newspaper, printed paper from administrative block) to external organizations for recycling or selling it to the *kabadiwalas* (who further sold it back to the industry). Old books were the only paper products reused by either keeping them for reference in library or giving them to students in need. Less than 50% schools were recycling or reusing cardboard boxes, decorative / craft paper and tetrapaks.

#### b. Electronic products

Only a portion of electronic items used in schools were sent for recycling to government approved recyclers. About one-third of the schools were discarding electronic products (like lighting equipment, old fans, computer monitors, generators and electronic appliances) to the landfill after use. Some schools were also giving them away to members of maintenance staff who needed them. Only three schools made an attempt to give a second life to old IT products by donating them to organizations that required them.

Electrical equipment like smart boards and projectors is a relatively new technology, thus none of the schools felt the need to recycle or discard this equipment. Based on the usage and wear and tear of equipment like printers, mobile phones and large appliances, these were either exchanged for new ones or discarded.

#### c. Plastic waste

Plastic waste like chips, candies and ice creams were usually generated in classrooms and canteen. Segregation of plastic was not a regular practice in most of the schools unless it was part of a recycling programme with an environment based organization. Results reveal that more than 65.0% of the schools were discarding their plastic waste. Only a few were segregating plastic waste for reuse or sending it for recycling to government authorized recycling plants.

#### d. Furniture products

As schools invest considerable portion of their funds in procuring furniture, majority of selected organizations (more than 88%) preferred reusing or recycling their furniture after minor repairs (like loose or broken legs, weak joints and polishing). Only three schools had purchased new furniture to replace old furniture and for new classrooms. The most commonly reused furniture items were cupboards and almirahs.

Table 4: Application of reuse and recycle of solid waste generated in Delhi schools

	REUSE	RECYCLE	LANDFILL
<b>a. PAPER WASTE AND PRODUCTS</b>			
1 Classroom paper	2 (07.7%)	20 (76.9%)	4 (15.4%)
2 Printed paper	0	20 (76.9%)	6 (23.1%)
3 Newspaper	0	21 (80.8%)	5 (19.2%)
4 Cardboard and cardboard boxes	1 (03.8%)	11 (42.3%)	14 (53.8%)
5 Old books	16 (61.5%)	5 (19.2%)	5 (19.2%)
6 Tetrapack	1 (03.8%)	10 (38.5%)	15 (57.7%)
<b>b. ELECTRONIC PRODUCTS</b>			
<b>Electronic Equipments</b>			
1 Computer monitor	3 (11.5%)	12 (46.1%)	11 (42.3%)
2 Computer accessories (Wires, CUP, etc)	3 (11.5%)	13 (50.0%)	10 (38.5%)
3 Smart class boards	0	0	0
4 Projector screen and monitor	0	0	0
5 Printer and printer cartridge	2 (07.7%)	13 (50.0%)	11 (42.3%)
6 Mobile phones	2 (07.7%)	13 (50.0%)	11 (42.3%)
7 CD / Hard drive / Pen drive / DVD	3 (11.5%)	14 (53.8%)	9 (34.6%)
8 Large electric appliances like Fridge,	3 (11.5%)	12 (46.1%)	11 (42.3%)
<b>Batteries &amp; Generators</b>			
1 Inverter Batteries	3 (11.5%)	12 (46.1%)	11 (42.3%)
2 Generator and its parts	2 (07.7%)	11 (42.3%)	13 (50.0%)
<b>Lighting System</b>			
1 Florescent tubes	0	4 (15.4%)	22 (84.6%)
2 Bulbs and other lighting equipment	0	4 (15.4%)	22 (84.6%)
3 Old fans	2 (07.7%)	5 (19.2%)	19 (73.1%)
<b>c. PLASTIC WASTE</b>			
1 Plastic bottles	3 (11.5%)	6 (23.1%)	17 (65.3%)
2 Plastic wrappers	1 (03.8%)	4 (15.4%)	21 (80.8%)
3 Plastic tubs and containers	3 (11.5%)	3 (11.5%)	20 (76.9%)
<b>d. FURNITURE PRODUCTS</b>			
1 Classroom Desks and chair	23 (88.5%)	1 (03.8%)	2 (07.7%)
2 Cupboards and Almirah	25 (96.1%)	0	1 (03.8%)
3 Above the Counter storage	23 (88.5%)	2 (7.7%)	1 (03.8%)
4 Below the Counter storage	22 (84.6%)	2 (7.7%)	2 (07.7%)
<b>e. GARDEN WASTE &amp; EQUIPMENT</b>			
1 Garden equipment	1 (03.8%)	2 (07.7%)	23 (88.4%)
2 Dead plants / dried leaves / twigs / etc	3 (11.5%)	17 (65.4%)	6 (23.1%)
3 Weeds	3 (11.5%)	14 (53.8%)	9 (34.6%)
<b>f. TEXTILES PRODUCTS</b>			
1 Towels	10 (38.5%)	16 (61.5%)	0
2 Sheets and covers	8 (30.8%)	18 (69.2%)	0
3 Apron, etc	5 (19.2%)	21 (80.8%)	0
<b>g. FOOD WASTE</b>			
1 Left over food from lunch box	5 (19.23%)	21 (80.8%)	0
2 Left over food from canteen	5 (19.23%)	21 (80.8%)	0
3 Fruits and fruit peels	6 (23.07%)	20 (76.9%)	0
<b>h. OTHER WASTE</b>			
<b>Metal Waste</b>			
1 Aluminium foil	0	0	26 (100.0%)
2 Old Metal dustbins / containers	3 (11.5%)	4 (15.4%)	19 (73.1%)
<b>Glass Waste</b>			
1 Glass bottles, beakers and test tubes	2 (7.7%)	4 (15.4%)	20 (76.9%)

n = 26 schools

**e. Garden waste and equipment**

Almost two-third of schools (65.38%) were involved in composting to produce manure. Plant remains like weeds, leaves and branches are also bio-degradable in nature and were composted. Gardening equipment generally doesn't wear out easily; thus, most of the garden equipment were discarded only after a stage where it could not be repaired any more.

### f. Textile products

Most of the textile products were used in laboratories where they are laundered and used regularly until torn. More than 60% of the schools were disposing off textile waste on an annual basis. However, nearly one-third of the schools reused sheets and covers as dusters. Aprons were also found to be discarded by majority of the schools (80.8%) annually.

### g. Food waste

Food waste comprising of left over food from canteen and lunch box, fruits and fruit peels is bio-degradable in nature, however more than 80% of the schools it. In most of the schools, food waste was found mixed with plastic, paper and packaging material, therefore, it was considered unfit for recycling until segregated.

### h. Other solid waste

More than 73% of the schools were found to be discarding metal and glassware. Items like aluminium cans and glassware were collected and segregated only when it was a part of a recycling project undertaken by the school.

## D. Quantum of solid waste generated in schools

Urban solid waste in Delhi Schools is a complex mixture of electronic, furniture, textiles, paper, plastic, food and garden waste. The analysis of the existing composition revealed that schools in Delhi have a huge quantum of solid waste to be managed. Table 5 reveals that only 19.01% of products were reused like old furniture items, textiles and old electric equipment like fans. The recyclable components including paper waste and electronic items comprised of less than 30% of the total solid waste generated in educational institutions.

**Table 5:** Quantum of solid waste (n=26)

		REUSE	RECYCLE	LANDFILL
1	ELECTRONIC PRODUCTS n = 286 (26 schools x 11 electronic product)	23 8.04%	113 39.51%	150 52.44%
2	FURNITURE PRODUCTS n = 104 (26 schools x 4 furniture product)	93 89.42%	5 4.80%	6 5.76%
3	TEXTILES PRODUCTS n = 78 (26 schools x 3 Textile product)	23 29.48%	0 0.00%	55 70.51%
4	GARDEN WASTE & EQUIPMENT n = 78 (26 schools x 3 garden product)	7 8.98%	33 42.30%	38 48.72%
5	PAPER WASTE & PRODUCTS n = 156 (26 schools x 6 paper product)	20 12.82%	87 55.70%	49 31.41%
6	PLASTIC WASTE n = 78 (26 schools x 3 Plastic product)	7 8.97%	13 16.66%	58 74.35%
7	FOOD WASTE n = 78 (26 schools x 3 food product)	0 0.00%	16 20.51%	62 79.49%
8	OTHER WASTE n = 78 (26 schools x 3 other product)	5 6.41%	8 10.25%	65 85.52%
<b>TOTAL (26 schools x 36 products = 936)</b>		178	275	483
<b>TOTAL PERCENTAGE</b>		<b>19.01%</b>	<b>29.38%</b>	<b>51.60%</b>

Analysis of product characterization revealed that 51.60% of the total waste generated in schools was disposed into landfill without segregation or treatment. It also indicated that more than 15.17% of the total discarded waste was organic in nature (textiles, food and paper waste) and 16.02% comprised of electronic waste (like computer parts, CD's, pen drives and printers).

Practicing source segregation to separate recyclables from reusable can greatly help in reducing the actual amount of solid waste going into landfill. Solid waste management in schools need complete change in perspective and prioritization of source segregation to improve the overall environment by reducing the total amount of waste going into landfill.

## V. Conclusion

Delhi schools are making a considerable contribution towards the total urban solid waste generated in the city as they accumulate tonnes of waste on a daily basis. Schools cater to almost 25% of the city's population and it is their responsibility to set example by practicing and imbibing healthy environmental attitude among students. Having a solid waste management plan to reduce, reuse and recycle waste should be a pre-requisite for every school.

Any intervention for management of solid waste is ineffective if it doesn't address the fundamental problem, i.e. absence of waste segregation at source. Most of the waste generated was ending up in landfill as little interest was taken by school authorities and staff to promote segregation for healthy and hygienic environment. Lastly, to address the critical issue, there is a need for schools to not only improve the management of collection and treatment of solid waste but also improve awareness among children to make it a part of their daily life at home, school and society. Educating young children about their immediate environment and the effect of human activities on the ecological system is essential, since instilling the right behaviour at a very early stage can prove beneficial in changing the attitudes of their families.

## VI. References

1. Nationsonline. Com. 2019. Population figures by countries, available at [www.nationsonline.org/oneworld/population-by-country.htm](http://www.nationsonline.org/oneworld/population-by-country.htm), accessed during June 21, 2019
2. Moneycontrol.com. 2019. India, China major contributors to green cover in past 20 years: NASA, available at [www.moneycontrol.com/news/trends/india-china-major-contributors-to-green-cover-in-past-20-years-nasa-3605091.html](http://www.moneycontrol.com/news/trends/india-china-major-contributors-to-green-cover-in-past-20-years-nasa-3605091.html), accessed during June 21, 2019
3. Karak, T., Bhagat, R.M. and Bhattacharyya, P. 2012. Municipal Solid Waste Generation, Composition, and Management: The World Scenario, *Critical Reviews in Environmental Science and Technology*, 42(15), 1509-1630.
4. De Lavega, R. M. C. 2004. Awareness, Knowledge, And Attitude About Environmental Education: Resp, University of Central Florida, USA.
5. UNESCO. 2009. Review of Contexts and Structures for Education for Sustainable Development, United Nations Educational, Scientific and Cultural Organization, USA.
6. Miezah K., Obiri-Danso, K., Kádár, Z., Fei-Baffoe, B. and Mensah, M.Y. 2015. Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana. *Waste Management*.
7. Census 2011. 2019. Delhi Population 2011, available at [www.census2011.co.in/census/state/delhi.html](http://www.census2011.co.in/census/state/delhi.html), accessed during June 21, 2019
8. Economic Survey of Delhi. 2019. Chapter 15: Education, available at [www.delhiplanning.nic.in/sites/default/files/15%29%20Education\\_0.pdf](http://www.delhiplanning.nic.in/sites/default/files/15%29%20Education_0.pdf), accessed during June 21, 2019
9. Phuntsho, S., Heart, S., Shon, H., Vigneshwaran, S., Dulal, I., Yangden, D. and Tenzin, U., (2010), Studying municipal solid waste generation and composition in the urban areas of Bhutan, *Waste Manage. Res.*, 28, 545.
10. Zhang, N., Williams, I.D. Kemp, S. and Smith, N.F. 2011. Greening academia: Developing sustainable waste management at Higher Education Institutions, *Waste Management*, 31, 1606–1616.
11. Rada, R.C., Bresciani, C., Girelli, E., Ragazzi, M., Schiavon, M. and Torretta, V. 2016. Analysis and Measures to Improve Waste Management in Schools, *Sustainability*, 8, 840.

