Chapter 12
Matrix Method for Evaluation of Existing Solid Waste Management Processes in Jalandhar City, Punjab, India

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Abstract Solid waste management is one of the most serious problems being faced by Indian cities due to increased urbanization and industrialization in India. The present study highlights the existing status of solid waste management practices in Jalandhar city, Punjab, India considering a dumpsite of Wariana village and Suchipind of Jalandhar and suggests remedial measures to the major problems being faced by the existing system of solid waste management. The waste generation of municipal solid waste in Jalandhar city was reported as 400 ton per day. A total of 350 ton of solid waste is disposed of in different disposal sites daily in the city. The per capita waste generation rate in Jalandhar is approximately 0.6 kg/capita/day. The collection efficiency of the municipal solid waste is reported about 70% in the city. The study also summarizes the 'wasteaware' benchmark indicators for the evaluation of the existing scenario of solid waste management in Jalandhar city and matrix method for comparing the overall score of the existing management of municipal solid waste of Jalandhar city with Chandigarh city. The overall score of the analysis of the matrix method for Jalandhar city was reported as 32% and the same for Chandigarh city was 46%. However, the quantification score of Jalandhar city was considerably lower than Chandigarh city. The analysis of matrix method suggested that the management of municipal solid waste in Jalandhar city can be categorized under the category of low index, whereas Chandigarh city was categorized under low–medium index.

Keywords Municipal solid waste · Open dumping · 'Wasteaware' benchmark indicators · Matrix method

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12.1 Introduction

Increased urbanization and industrialization has led to severe environmental pollution in the cities due to the drastic increase in the generation of solid waste (Puri et al. 2008; Sethi et al. 2013). Population growth and rising living standards contribute to an increase in the amount and variety of solid waste generated in the countries. In particular, solid waste management has been a pertinent issue for developing countries (Shekdar 2009). The poor waste management practices are primarily due to the lack of authentic data and information to analyse the waste management practices (Chang and Davilla 2007; Hancs et al. 2011; Katiyar et al. 2013). The population of India is reported as 1083 million in 2001 and 1253 million in 2013 (Census report 2011). In general, Indian megacities including [Ahmedabad (6.3 million), Hyderabad (7.7 million), Bengal (8.4 million), Chennai (8.6 million), Kolkata (14.1 million), Delhi (16.3 million) and Greater Mumbai (18.4 million)] having a drastical increase in population as reported by Kumar et al. (2009). The substantial growth in population is the major contributor of solid waste in country (Anand 2005). There is no proper statistics about the nature, volume, collection, transportation and dumping of solid wastes generated in city (Sharholy et al. 2008; Ramachandra 2009). Since there is a lack of proper management of solid wastes, its increased generation coupled with lack of public awareness makes it potentially effective in causing environmental and human health effects. Further, it also reduces the visual aesthetics of the surrounding environment. In India, the existing status of municipal solid waste management is highly unsatisfactory. Currently, about 960 million tonnes of solid waste is being generated annually as by-products during municipal, industrial, mining, agricultural and other processes in India (Pappu et al. 2004). The per capita waste generation is 0.17 kg/capita/day in small towns and 0.62 kg/capita/day in the cities of India (Kumar et al. 2009; Modak et al. 2012). The population growth of major cities in India has been shown in Table 12.1. The statistics of municipal solid waste generated in different states in India has been shown in Table 12.2 and the waste generation rate of major cities in India has been shown in Table 12.3.

Solid waste thus generated in India is not managed properly due to the poor management of municipal corporation of the cities; about 90% of the waste is disposed of as an open dumping in the ground and hence contributes to the

Table 12.1 Population growth of major cities in India (Census 2011)

Sl. No.	City name	Population growth (10^6)
1.	Ahmedabad	6.3
2.	Hyderabad	7.7
3.	Bangalore	8.4
4.	Chennai	8.6
5.	Kolkata	14.1
6.	Delhi	16.3
7.	Mumbai	18.4

Table 12.2 Statistics of municipal solid waste generated in different states in India (CPCB 2015)

Sl. No.	Name of the state/UT	Municipal solid waste MT/day (2009–2012)
1.	Andaman and Nicobar	50
2.	Andhra Pradesh	11,500
3.	Arunachal Pradesh	93.802
4.	Assam	1146.28
5.	Bihar	1670
6.	Chandigarh	380
7.	Chhattisgarh	1167
8.	Daman Diu and Dadra	41
9.	Delhi	7384
10.	Goa	193
11.	Gujarat	7378.775
12.	Haryana	536.85
13.	Himachal Pradesh	304.3
14.	Jammu and Kashmir	1792
15.	Jharkhand	1710
16.	Karnataka	6500
17.	Kerala	8338
18.	Lakshadweep	21
19.	Maharashtra	19.204
20.	Manipur	112.9
21.	Meghalaya	284.6
22.	Mizoram	4742
23.	Madhya Pradesh	4500
24.	Nagaland	187.6
25.	Orissa	2239.2
26.	Puducherry	380
27.	Punjab	2793.5
28.	Rajasthan	5037.3
29.	Sikkim	40
30.	Tamil Nadu	12,504
31.	Tripura	360
32.	Uttar Pradesh	11.585
33.	Uttaranchal	752
34.	West Bengal	12,557
Total		127,485.107

environment pollution. The major problem of ineffective management of solid waste is due to deficit of requisite budgetary provisions for the management of solid waste (Rana et al. 2015).

Table 12.3 Waste generation of major cities in India (CPCB 2015)

Region/city	MSW (TPD)	Compostable (%)	Recyclables (%)	Inerts (%)	Moisture (%)	Cal. value (kcal/kg)
Metros	51,402	50.89	16.28	32.82	46	1523
Other cities	2723	51.91	19.23	28.86	49	2084
East India	380	50.41	21.44	28.15	46	2341
North India	6835	52.38	16.78	30.85	49	1623
South India	2343	53.41	17.02	29.57	51	1827
West India	380	50.41	21.44	28.15	46	2341
Overall Urban India	130,000	51.3	17.48	31.21	47	1751

The present study focuses on the existing solid waste management systems practised in Jalandhar city, Punjab, India. The study also employs the 'Wasteaware Benchmark' techniques and matrix method for grading the efficiency of the existing system. The paper also proposes suitable remedial measures for improving the existing system of municipal solid waste management carried out at these sites.

12.2 Methodology

12.2.1 Site Location

Jalandhar city lies in the coordinates of 31.3260°N and 75.5762°E with a population of 8,73,725 (Census 2011) with an MSW generation of 400 TPD with a collection efficiency of 70% which is openly dumped in land. The location of study area has been shown in Fig. 12.1.

12.2.2 'Wasteaware' Benchmark Indicators

The problem of municipal solid waste management is getting more awful due to diverse factors including poor technical and less financial resources, deficit of enforcement of regulations, lack of coordination between the authorities and scarcity of policies (Kumar et al. 2009).

The major downside of the ineffectual municipal solid waste management system is the absence of relentless data for the designing and interpretation of effective solid waste management system for comparative basis. Integrated solid waste management benchmark indicators are the effective tool to analyse the performance of recycling and municipal solid waste management of the city and municipality. The basic principle of benchmark indicators is to allow the city to determine or

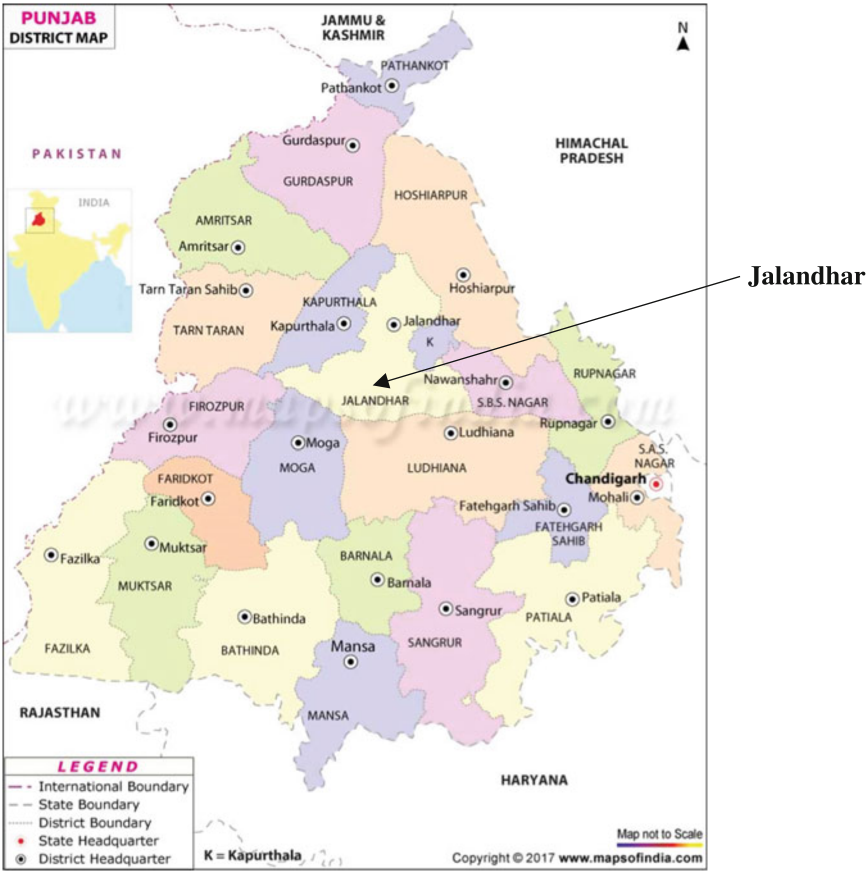

Fig. 12.1 Location of study area in Punjab

judge its performance of waste management services with different cities. Moreover, it also provides information for decision-making on primary issues regarding funds for the improvement of waste management services.

The ‘wasteaware’ benchmark parameters integrate both qualitative and quantitative indicators (Wilson et al. 2013, 2015) for determining the performance of municipal solid waste management systems practiced in different locations. In the quantitative analysis of waste management, the parameters include public health collection, environmental controlled disposal and resource management—reuse, reduce and recycling and the qualitative indicators consolidates governance parameters like user and provider inclusivity; financial sustainability; and the national policy framework and local institutions (Wilson et al. 2013, 2015).

12.2.3 Matrix Method

The quantification method has been employed for the consideration of existing municipal solid waste management system (Rana et al. 2015). In this context, the 'wasteaware' benchmarks utilized grading system including low (*L*), low/medium (*L*/*M*), medium (*M*), medium/high (*M*/*H*) and high (*H*), a five points classification has been assigned to each of these benchmarks. The above grading systems (*L*, *L*/*M*, *M*, *M*/*H* and *H*) were utilized by assigning each of them a classification point such as ($L = 1$, $L/M = 2$, $M = 3$, $M/H = 4$, $H = 5$). The matrix method has been successfully used to evaluate the functioning of the MSW management in tri-city locations of Chandigarh, Mohali and Panchkula (Rana et al. 2015, 2017) and at selected study locations in Himachal Pradesh (Sharma et al. 2018).

12.3 Results and Discussions

12.3.1 Assessment of Existing Municipal Solid Waste (MSW) Management in Jalandhar City

Generation of MSW Jalandhar city lies in the area of 110 m^2 with a total number of 60 wards as reported by Census (2011). The estimated garbage generation is 400 ton per day in the city and approximately 350 ton of waste is collected and disposed of daily in the dumpsites. The solid waste is generated from residential, commercial, institutional, construction and demolition, industrial, agriculture, etc. and the sources of solid waste are rubbish, garbage, ashes, street waste, bulk waste and hazardous waste (Puri et al. 2008). The area of the city is scattered into three zones including residential zone (85%), industrial zone (10%) and mixed zone (5%). The physical characterization of municipal solid waste has been summarized in Table 12.4.

Table 12.4 Physical characterization of waste (Puri et al. 2008)

Sl. No.	Parameters	Range	Average
1.	Metal (ferrous)	0.00–1.00	0.01
2.	Metal (non-ferrous)	0.00–0.04	0.13
3.	Earth-ware stone	0.50–15.00	5.17
4.	Glass/ceramics	0.00–2.10	0.57
5.	Fine earth	19.92–25.72	24.15
6.	Paper/cardboard	0.2–10.80	3.43
7.	Wooden matter	0.00–0.30	0.09
8.	Rags	0.10–9.80	3.95
9.	Rubber/leather	0.00–4.00	1.31
10.	Plastics	3.20–14.5	7.42
11.	Organic matter	6.90–68.10	44.53

Collection of MSW The type of waste containers and the area of waste storage are mainly based on the frequency and method of solid waste collection (both inorganic and organic waste). It is reported that more than 450 collection bins have been placed roadside in the city and around 60 DP bins of 3.5 m^3 capacities are placed at sensitive littering points. The sweeping frequency of waste has been reported twice in a day under the supervision of ward supervisor. Individual municipal solid waste collectors are also involved and every house is charged a fee of rupee 50 per month for the collection of municipal solid waste. These waste collectors informally separate the waste into biodegradable, paper, rubber, plastics, glass and metals and then, waste is transferred to Sehaj Safai Kendra's (SSKs). The considerable downside of waste management in Jalandhar city is ill-suited collection of municipal solid waste. The solid waste generated in the city is stored in common bins without any prior segregation of waste. There is no provision of separate bins for the dry waste and the wet waste. The rate of waste generation is more and the dustbins for the collection of solid waste are less in number. The insufficient number of dustbins contributes to the littering and spilling of waste and hence contributes to insanitary conditions of the city. It is observed that during the survey of solid waste management plans in the city, there is no provision of daily door-to-door collection of waste. The solid waste is collected from the collection bins from different locations of the city and from the residential and commercial sectors of the city. It is recommended from World Health Organization that the waste is collected through cart pullers and handcarts. The cart pullers used to segregate the paper, plastic, polythene, metal, leather, etc. which is sold to the Kabariwala. In this way, the biodegradable and recycled waste may get separated from inert waste. This collection system is economically viable and also reduces the volume of solid waste in the dumping sites. But in actual practice, the waste is not sorted and segregated in accurate manner and almost all of the biodegradable waste is dumped in open land.

Transportation of MSW There is outrageous need of the expenditure on manpower, vehicles and other resources to improve the efficiency of solid waste management. The conditions of the transportation vehicles depend on the physical layout of the roads, cost of manpower available and maintenance provisions. The vehicles provided by municipal authority for the transportation of waste to the dump sites in Jalandhar includes tippers, loaders, bulldozers, compactor, three wheelers, tractor trolleys, dumper placer hydra cranes, etc. The transportation methodology is divided into three categories in the city including household waste transportation, commercial waste transportation and commercial routes being followed by the workers of municipal corporation of the city. The household waste is collected by waste pickers on rickshaw Rehra's and transported to secondary dumps. Finally, the secondary dumps loaded and transported to Wariana and Suchipind dumpsites. The commercial waste is collected by municipal corporation vehicles such as Tata Ace and Refuse Compactors. The vehicle named Tata Ace

Table 12.5 Number of machineries used for the transportations of municipal solid waste (city profile report of municipal corporation, Jalandhar)

Sl. No.	Name of machinery	Number of machinery
1.	Tippers	20
2.	JC/loaders	09
3.	Bulldozer tracked	02
4.	Three wheelers	27
5.	Tata Ace/Bolero/Ashok Leyland	20
6.	Tractor trolleys including hired	11 + 16 (Hired)
7.	Compactors	03 (Hired)
8.	Dumper placer	09

dumps the commercial waste at secondary collection points and then refuse compactors carry it to dumpsites for disposal. There are five commercial routes for the transportation of waste to the dumping lands. The name of machinery and number of machinery has been shown in Table 12.5.

In this context, it is critically observed from the survey that most of the vehicles are worn out and no maintenances had been carried out of these vehicles since the past years. Apart from this, one of the major drawbacks of transportation system is that waste is transported mostly in open trucks and vehicles which cause littering of waste here and there in the roads and thereby made habitat for mosquitoes (Rana et al. 2015).

Disposal of MSW The daily disposal of municipal solid waste is imperative due to the presence of high organic matter of municipal solid waste that may cause nuisance and unhygienic condition of the surroundings (Kumar et al. 2009). The waste collected from different sources from the Jalandhar city is disposed of in Wariana dumpsite (100 ton of solid waste per day) and in Suchipind dumpsite (250 ton of solid waste per day) that has been used for last 30 years. Presently, all types of solid waste consisting of industrial, biomedical, slaughterhouse and municipal solid waste are dumped on this landfill site. According to the management and handling Rules 2000, only inert waste should be disposed of in the landfills and the remaining waste should be transferred to the processing units. It has been already discussed that the disposal sites are used over 30 years old, and as such, no facility of leachate collection system, liner system and proper gas collection facilities has been constructed. Therefore, it is a threat to the surface and groundwater quality because of the permeation of leachate in the soil. Emission of landfill gases (LFGs) at the dumping site can be clearly observed causing pungent smell and affecting the health of the workers who work in the vicinity of the landfill site. However, no scientific observations for the right quantity of greenhouse gases produced are made to test the concentration of landfill gas (LFGs).

12.3.2 'Wasteaware' Benchmark Indicators

'Wasteaware' benchmark indicator is the index system to evaluate the pollution level by municipal solid waste (Rana et al. 2015). In this context, 'wasteaware' benchmark indicators which include qualitative and quantitative indicators have been addressed in Sect. 2.2 (Wilson et al. 2013, 2015). In this context, the benchmarks for Jalandhar city have been evaluated and are shown in Table 12.5 by adopting the procedure (Wilson et al. 2015). Apart from this, the generated benchmark for Jalandhar city has also been compared with the benchmarks of Chandigarh city. It is observed from Table 12.5 that overall municipal solid waste generated in Jalandhar city is substantially lower than the overall municipal solid waste generated in Chandigarh because of the difference in population of Chandigarh city is more than that of the Jalandhar city. The colour coding in the table indicated that red colour presented for low index, yellow colour for medium index and green colour for high index. In this context, it was observed from the evaluation of 'wasteaware' benchmark parameters that the collection efficiency and waste collection services under the category of qualitative indicators of Jalandhar city lies in low/medium index (*L*/*M*) as compared to Chandigarh city that is having collection efficiency lies in medium/high index (*M*/*H*) (Rana et al. 2015). Apart from this, for the Environmental control and 3R's facilities, both Jalandhar and Chandigarh city were classified under the category of the low index. The 'wasteaware' analysis also reveals that for the qualitative indicators including public health parameters and environmental control measures, Jalandhar city lies in low/medium index (*L*/*M*) and for the same qualitative parameters, Chandigarh city lies in medium index (Rana et al. 2015). The 'Wasteaware' benchmark indicators for Jalandhar city compared with Chandigarh city has been shown in Table 12.6.

Quantification of Indicators Using Matrix Method Matrix method is further used for the quantification of the 'weights' that has been allocated to both quantitative and qualitative parameters of 'wasteaware' benchmarks for Jalandhar and the evaluation comparison with Chandigarh city which has been summarized in Table 12.7 and summary of scores obtained through matrix method has been summarized in Table 12.8.

The overall score of analysis of Matrix method for Jalandhar city was reported 32% and similarly, the score for Chandigarh city was 46%. Hence, it is clearly showed that the quantification score of Jalandhar city was considerably lower than Chandigarh city (Rana et al. 2015). The matrix analysis reported that the management of municipal solid waste generated at study location Jalandhar can be categorized under low index category and the scores of Chandigarh city lies under low–medium index. Further analysis revealed that weightage obtained from quantitative parameters of 'wasteaware' analysis was reported (26%) for Jalandhar city, whereas it was slightly more for Chandigarh city (40%) because it is a planned and designed city and hence it has a marginal advantage in comparison to other Tier-II and Tier-III cities (Rana et al. 2015). Moreover, the score for governance factors of Jalandhar and Chandigarh were reported as 40 and 55% respectively.

Table 12.6 'Wasteaware' benchmark indicators for Jalandhar city

Sr. No.	Category	Indicator	Jalandhar City	Chandi-garh City
Background information of the city				
1	Country Income Level	World Bank Indicator Level	Lower-Middle	Lower-Middle
		GNI per Capita	$1,140	$1,140
B2	Population of the City	Total Population of the City	8,73,725	1,055,450
B3	Waste Generation	MSW Generation (tons/year)	127750	135050
W1	Waste per Capita	MSW per capita (Kg per year)	146	128
W2	Waste Composition		3 key fractions – as % wt. of total waste generated	
W2. 1	Organic	Organics (food and green wastes)	44.53%	52%
W2. 2	Paper	Paper	3.43%	6%
W2. 3	Plastic	Plastic	7.42%	7%
1.1	Public health - Waste collection	Waste collection coverage	70% (L/M)	90% (M/H)
1C	-	Quality of waste collection service	70% (L/M)	90% (L/M)
2	Environmental control- waste treatment and disposal	Controlled treatment and disposal	10% (L)	30% (L)

(continued)

Table 12.6 (continued)

2E	-	Degree of environmental protection in waste treatment and disposal	0% (L)			0% (L)		
3	3Rs - reduce, reuse and recycling	Recycling rate	0% (L)			0% (L)		
3R		Quality of 3Rs provision	5% (L)			17% (L)		
6N	Sound institutions, proactive policies	Adequacy of national SWM framework	60% (L/M)			60% (L/M)		
6L	Degree of Institutional coherence		70% (L/M)			75 % (M)		
4U	User inclusivity	User inclusivity	68% (L/M)			75 % (M)		
4P	Provider inclusivity	Degree of provider inclusivity	65% (L/M)			78 % (M)		

12.4 Key Recommendations for Improvement of Municipal Solid Waste Management at the Selected Study Locations

12.4.1 Source Segregation

Source segregation is most important key parameter for the improvement of solid waste management system. Except for inert waste, rest of all the waste including paper, plastic, metal, glass and rubber is recyclable in nature. In this context, proper handling, collection and segregation of waste should be implemented in the city so that dry waste should be recycled properly. It is possible only because of community partnership and public–private ownership for the strategy of municipal solid

Table 12.7 Weightage assignment for evaluation using matrix method

Sl. No.	Category	Indicator	Jalandhar city	Chandigarh city
Quantitative indicators (public health, environmental control, 3R's)				
1.1	Public health	Waste collection coverage	70% (*L*/*M*) (2)	90% (*M*/*H*) (4)
1C	Waste collection	Waste collection services	70% (*L*/*M*) (2)	90% (*M*/*H*) (4)
2	Environment control facilities	Control treatment and disposal	10% (*L*) (1)	30% (*L*) (1)
2E	Waste treatment and disposal	Degree of environmental protection	0% (*L*) (1)	0% (*L*) (1)
3	3R's—reduce, reuse and recycling	Recycling rate	0% (*L*) (1)	0% (*L*) (1)
3R		Quality of 3R's provisions	5% (*L*) (1)	17% (*L*) (1)
Qualitative indicators (governance factors)				
4U	User inclusivity	User inclusivity	*L*/*M* (60%) (2)	*M* (75%) (3)
4P	Provider inclusivity	Provider inclusivity	*L*/*M* (70%) (2)	*M* (78%) (3)
6N	Sound, institutions proactive policies	Adequate national framework	*L*/*M* (60%) (2)	*L*/*M* (60%) (2)
6L	–	Degree of institutional coherence	*L*/*M* (65%) (2)	*M* (75%) (3)

waste management plans. Awareness programmes should be assembled in order to motivate the residents for source segregation of waste and promoted recycling and reuse of segregated waste material. At present, there is no recycling unit situated in Jalandhar city that is unfavourable practise. The public should be encouraged to manage two collection bins for wet, dry and recyclable waste so that the waste must be initially segregated at the household level before reaching to the dumpsites. The municipality should have commenced the provisions of closed-type garbage containers for the collection of waste so that littering and spilling of waste should be avoided.

12.4.2 *Provision of Underground Collection Bins*

It is critically suggested that the authorities of municipal corporation of the city should have focused on the issue of closed containers and underground bins.

Table 12.8 Summary of scores obtained through matrix method

Sl. No.	Category	Indicator	Jalandhar city	Chandigarh city
Quantitative indicators (public health, environmental control, 3R)				
1.1	Public health—waste collection	Waste collection coverage	2	4
1C		Quality of waste collection service	2	4
2	Environmental control—waste treatment and disposal	Controlled treatment and disposal	1	1
2E		Degree of environment protection in waste treatment and disposal	1	1
3	3R's—reduce, reuse and recycling	Recycling rate	1	1
3R		Quality of 3R's provision	1	1
Total score (quantitative indicators)			08	12
Maximum score			30	30
Weightage (%)			26	40
Qualitative indicators (governance factors)				
4U	User inclusivity	User inclusivity	2	3
4P	Provider inclusivity	provider inclusivity	2	3
6N	Sound institutions proactive policies	Adequacy of national SWM framework	2	2
6L	–	Degree of institutional coherence	2	3
Total score (quantitative indicators)			08	11
Maximum score			20	20
Weightage (%)			40	55
Total score (overall)			08 + 08 = 16	12 + 11 = 23
Total maximum score			30 + 20 = 50	30 + 20 = 50
Overall weightage (%)			32	46

There should be separate collection bins for dry waste (paper, plastic) and wet waste (organic waste). The non-biodegradable and dry waste such as paper, plastic, metal and glass should be recycled and sent to the authorized recyclers for its use in the manufacturing of new materials. The advantage of implementation of such strategy are better environment (no bad odour from smelly dirty bins), secured collection (no overflowing bins or stray animals feeding on waste), increase awareness among citizens, cost saving (no broken and dirty garbage bins) and moreover easy to install, collect and dispose garbage and hence, an effective alternative to present situation.

12.4.3 Composting/Vermicomposting

It is further reported from the literature study of characterization of municipal solid waste in Jalandhar that MSW is rich in organic waste. The past studies of characterization of waste in Jalandhar revealed that most of the waste is biodegradable in nature. In this context, composting and vermicomposting is the best alternative for the decomposition and stabilization of organic fraction of waste. The bio conversion of municipal solid waste into soil enriches the natural fertility of soil. In this context, a composting facility was operated by the M/S Punjab Grow more fertilizers Pvt. Ltd. since 2003 but at present the facility is non-working. (Personal Communication with the Municipal Engineer of Jalandhar). In this context, there is outrageous need of providing adequate training to the operating staff for reanimating of the existing compost plant.

12.4.4 Refused Derived Fuel Plant

Presently, there is no such waste treatment facility of municipal solid waste in Jalandhar city. The installation of RDF plant is one of the feasible alternatives that can be used as a waste processing facility. The literature study on characterization of solid waste in Jalandhar city revealed the composition of paper waste which varied in the range of 3–10%, plastic waste varied in the range of 6–14% and major fraction of organic waste varied in the range of 40–44% and is found suitable for the treatment of solid waste in the city (Puri et al. 2008; Sethi et al. 2013).

12.4.5 Construction of Sanitary Landfill

The survey of the study area revealed that the waste is disposed of in open land in an unscientific manner. The open dumping of waste may cause health hazard issues and having environmental pollution (Puri et al. 2008). In this context, it is strictly suggested to construct engineered landfill system with liner system, leachate collection and removal system, gas collection facility and final cover system. After sorting the biodegradable organic fraction for bioprocessing and recyclable waste to manufacturing units, only the inert material should be disposed of into sanitary landfills. It should be noted that compaction is the mandatory factor while deposition of waste in order to maintain the stability and increase the capacity of closure.

12.5 Conclusion

Solid waste management is the globally concerned occurrence in the present scenario. This paper revealed an expressive image of the present situation in municipal solid waste management under the perspective of the citizens and municipal authorities. There is a dreadful need to educate local authorities and citizens of the city to reinforce environmental sustainability, public health, reduction and segregation at the source, reuse and recycling of waste. Further, it has been observed that the lack of resources including infrastructure, suitable data and planning, financing issues are the major limitations in the municipal solid waste management system. The overall survey showed the per capita waste generation rate in Jalandhar city is 350–400 ton per day with the collection efficiency of 70% that proves ineffectual for the municipal solid waste management system. The paper also focussed on the 'wasteaware' benchmark indicators and the quantification analysis by matrix method system for the study region Jalandhar city and the evaluation comparison with Chandigarh city. The results clearly showed the poor performance of environmental control methods including the collection and treatment of waste, disposal of waste, 3R's facilities, etc. in Jalandhar city. In this context, some of the remedial measures were suggested that must be incorporated by municipal corporations of Jalandhar city for the intensification of solid waste management including sufficient number of collection bins to avoid spilling of waste, facilities of new and advanced machines for segregating and recycling facilities. It is further expected from the study that the adjoining land of 2.25 acres acquired and processes will be started very soon to develop it as sanitary landfill (SLF). Another MSW processing facility will be planned in the city catering to the requirement of 27 cluster urban local bodies (ULBs) including Jalandhar. It is critically observed that there is no such facility of liner system, leachate collection and transfer system, gas monitoring facilities and final cover system for the disposal of solid waste. Open dumping of waste creates annoyance for the health of people as well as aesthetic appearance of the environment. Hence, open dumps should be avoided and waste should be disposed of in sanitary engineered landfill systems.

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