Comparative Analysis of Solid Waste Management Processes in Himachal Pradesh and Punjab

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Abstract. The study compiles the overview of existing municipal solid waste management processes in Himachal Pradesh. The physical characterization of municipal solid waste has also been assessed to provide the baseline data for the municipalities of respective regions to achieve the purposive waste management goals. It is mandatory for the municipal authorities to quantify and characterize the municipal solid waste in order to successful management of solid waste. The paper discusses the assessment of existing municipal solid waste processes of two municipal corporation regions of Himachal Pradesh and the comparative analysis of waste assessment with Jalandhar region of Punjab, India using Matrix method. The paper also conducted the 'wasteaware' benchmark indicators for the evaluation of solid waste management processes in Himachal Pradesh. The study of physical characterization revealed that the waste of Himachal Pradesh is rich in organic waste 62.01% (Shimla), 55.12% (Dharamshala) being followed by paper waste however the municipal solid waste of Jalandhar are also having maximum amount of organic waste but the second highest fraction is of plastic waste. The 'waste aware' benchmark indicators study revealed that Himachal Pradesh has better waste management practices than Jalandhar, Punjab.

Keywords: Municipal solid waste · Illegal dumping
'waste aware' benchmark indicators · Matrix method

1 Introduction

Solid waste management is one of the mandatory services that must be provided by municipal authorities to maintain the environment clean and safe. The condition of waste management has becoming more critical due to the rapid growth in urbanization and industrialization (Sharholy et al. 2008; Katiyar et al. 2013). The drastic increase in the population and hence growth in solid waste causes pollution of environment including air, water and soil (Puri et al. 2008; Sethi et al. 2013). The poor waste management practices are mainly due to the unavailability of veritable data and information to examine the waste management practices (Chang and Davila 2007; Shekdar et al. 2009). The population of India is outlined as 1083 million in 2001 and accordingly 1253 million in 2013 according to the Census report, 2011. The per capita

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per day waste generation is 0.17 kg/capita/day in smaller towns and 0.63 kg/capita/day in the big cities of India (Kumar et al. 2009; Modak et al. 2012). The solid waste produced in India has not managed in the adequate manner due to the lack of poor and improper management of Municipal Corporation authorities of the cities. In general, 90% of the waste is disposed illegally in the land, thus become the major contributors to the environment pollution (Rana et al. 2015; Rana et al. 2018). The present study gives the overview of waste management practices and physical characterization of solid waste in the municipal corporation cities (Shimla and Dharamshala) in Himachal Pradesh, India. In addition, the matrix method has been determined for the comparative analysis of the study regions with Jalandhar, Punjab. The description of study areas has been shown in Table 1 and the location of study areas has been shown in Fig. 1.

2 Methodology

2.1 Site Locations

See table and figure.

Table 1. Description of study areas

City	Longitude	Latitude	Waste generation
Shimla	31.1048°N	77.1734°E	90 TPD
Dharamshala	32.2190°N	76.3234°E	25 TPD

Fig. 1. Location of study areas

2.2 Characterization of Municipal Solid Waste

The sampling process was carried out for the physical characterization of municipal solid waste according to ASTM-D 5231-92. The municipal solid waste around 1000 kg was transported to the dumping grounds through transportation vehicles including trucks and tippers. The waste was unroll on the plastic sheet and then mixed properly in order to make the analogous mixture of the waste. Out of total 1000 kg of waste, 100 kg sample was withdrawn randomly at each day of the 10 days sampling period in order to acquire representative waste samples. The municipal solid waste acquired was sorted manually by the rag pickers (Rana et al. 2018).

2.3 'Wasteaware' Benchmark Indicators

Benchmark indicators are the efficient tool for the assessment of municipal solid waste management strategy of the city. The elemental principle of benchmark indicators is to allow the city to understand its performance of municipal solid waste management services and comparison with the waste management practices of different cities. However, it also provides information for decision making on prime issues regarding funds for the improvement of waste management services. The 'wasteaware' benchmark parameters integrated both qualitative and quantitative indicators (Wilson et al. 2013; Wilson et al. 2015). In the Quantitative analysis of waste management, the parameters include Public health collection, environmental controlled disposal and resource management and the qualitative indicators unite governance parameters including user and provider inclusivity, financial sustainability, national policy framework and local institutions.

2.4 Matrix Method

The matrix method is the method of quantification that has been enlisted for the deliberation of existed 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 point classification has been allocated to 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) (Rana et al. 2015; Sharma et al. 2018).

3 Results and Discussions

3.1 Assessment of Existing Municipal Solid Waste Management in Shimla and Dharamshala

3.1.1 MSW Generation

The average daily waste generation in Shimla city is reported as 90 tons per day and waste generation in Dharamshala is reported as 25 tons per day. The quality and quantity of municipal solid waste generated does not remain the same throughout the seasons but it shows variation during different seasons because of enormous floating population due to touristic activities. The sources of solid waste are residential, institutional, commercial, inert, industrial, agriculture etc. The physical characterization of municipal solid waste has been summarized in Table 2.

The characterization of the municipal solid waste revealed that out of total waste generated in Himachal Pradesh, the highest fraction of waste is the organic waste including vegetables, food and fruits etc. Paper waste formed the second highest fraction out of the total waste generated in Himachal Pradesh. The proportion of plastic has been found very low in Himachal Pradesh because the use of plastic has been banned in Himachal Pradesh since 2003. However, the reported literature showed the fraction of plastic waste in Chandigarh (7%), Jalandhar (9%), Bhopal (10%) that was lesser than Himachal Pradesh (Rana et al. 2018).

Table 2. Physical characterization of waste

Sr. No.	Parameters	Shimla	Dharamshala
1.	Density (Kg/m^3)	542.23 ± 27.32	527.02 ± 22.14
2.	Organic waste	62.01 ± 3.22	55.12 ± 1.45
3.	Paper	21.32 ± 2.45	19.11 ± 0.33
4.	Plastic	5.50 ± 1.99	7.05 ± 0.71
5.	Glass	1.34 ± 0.75	2.48 ± 0.22
6.	Metal	1.92 ± 0.06	2.09 ± 0.39
7.	Inert	4.89 ± 1.02	5.23 ± 0.24
8.	Rubber	2.11 ± 1.24	3.68 ± 1.67
9.	Textile	1.10 ± 0.66	5.24 ± 1.14

3.1.2 Collection of MSW

There is lack of adequacy in the system of municipal solid waste collection in Shimla city. The collection of waste at household level has been started but there is no provision of segregation of waste. No doubt, the dumpers have been placed at different locations in the city but without the consent of need or having no such data about the quantity of waste generation in different places.

Apart from this, Dharamshala city has somewhere improved scenario of waste collection system. Street sweeping is carried out in all 365 days by more than 130 workers from morning 7:30 am to 11:30 am and 2:00 pm to 4:00 pm covering all the roads of the city. About 188 km roads are swiped by more than 130 street sweepers on a daily basis. But no provision of waste segregation is noticed in the city.

3.1.3 MSW Transportation

The condition of transportation vehicles depend on the physical layout of the roads, manpower available and the funds allotted for maintenance provisions. The vehicles provided by municipal authority for the transportation of waste to the dump sites in Shimla city includes tippers, loaders, bulldozers, compactor, three wheelers, tractor trolleys etc. and the vehicles provided by municipal authorities in Dharamshala includes crane mounted truck, container lifting devices, jeep, auto rickshaw etc. In particularly, it is observed in both of the regions that most of the vehicles are worn out and lack of maintenances occurred that become the reason of inadequate management of waste. Moreover, the municipal solid waste is transported mostly in an open trucks and vehicles which cause littering of waste in the roads and thereby generation of flies and mosquitoes are supposed to occur (Rana et al. 2015).

3.1.4 MSW Disposal

The waste collected from different sources from the Shimla city and Dharamshala city is openly disposed of in the dumpsites. Currently, all types of solid waste consisting industrial, biomedical, slaughterhouse and municipal solid waste dumped on the disposal sites. According to the management and handling Rules 2000, only inert waste should be disposed of in the landfills and remaining waste should be transferred to the processing units. There is no such facility of leachate collection system, liner system, gas collection

Table 3. 'Waste-aware' benchmark indicators for Himachal Pradesh and Jalandhar city

Sr. No.	Category	Indicator	Jalandhar City	Himachal Pradesh
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	6,856,509
B3	Waste Generation	MSW Generation (tons/year)	109000	176000
W1	Waste Composition		3keyfractions–as % wt.oftotalwaste generated	
W1.1	Organic	Organics (food and green wastes)	44.53%	58.56%
W1.2	Paper	Paper	3.43%	20%
W1.3	Plastic	Plastic	7.42%	6%
1.1	Public health-Waste collection	Waste collection coverage	70% (L/M)	72% (L/M)
1C	-	Qualityof waste collection service	70% (L/M)	80% (M/H)
2	Environmental control-waste treatment and disposal	Controlled treatment and disposal	10% (L)	15% (L)
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		Qualityof 3Rsprovision	5% (L)	10% (L)
6N	Sound institutions,proactive policies	Adequacy of national SWM framework	60% (L/M)	64% (L/M)
6L	Degree of Institutional coherence		69% (L/M)	72% (L/M)
4U	User inclusivity	User inclusivity	68% (L/M)	71% (L/M)
4P	Provider inclusivity	Degree of provider inclusivity	65% (L/M)	73% (L/M)

Keys for colour coding

Red colour - low index
Yellow colour - medium index
Green colour - High index
Red/yellow - low/medium
Yellow/green - medium/high

facilities and monitoring wells in the disposal sites. Therefore, it is a threat to the surface and ground water quality because of the permeation of leachate in the soil.

3.2 'Wasteaware' Benchmark Indicators

3.2.1 System Analysis Using 'Wasteaware' Benchmark Indicators

The 'Wasteaware' Benchmark indicators for Himachal Pradesh and Jalandhar city has shown in Table 3 that the municipal solid waste generated at Himachal Pradesh is considerably higher than the waste generated in Jalandhar. In this context, red, yellow and green colours indicated low index (L), medium index (M) and high index (H) respectively. It was observed from the evaluation of 'wasteaware' benchmark parameters that the qualitative indicators collection efficiency and waste collection services (Public Health parameters) of Jalandhar city can be categorized in low/medium index (L/M) but the collection efficiency in Himachal Pradesh lies in medium/high index (M/H). Apart from this, for the Environmental control and 3R's facilities, both Himachal Pradesh and Chandigarh city were classified as low index. The 'wasteaware' analysis also reveals that for the qualitative indicators, Jalandhar city and Himachal Pradesh both lies in low/medium index (L/M). The weightage assignment and scores summary has been shown in Tables 4 and 5.

Table 4. Weight-age assignment for evaluation using matrix method

Sr. No.	Category	Indicator	Jalandhar city	Himachal Pradesh
Quantitative indicators (Public health, Environmental control, 3R's)				
1.1	Public health	Waste collection coverage	70% (L/M) (2)	72% (L/M) (2)
1C	Waste collection	Waste collection services	70% (L/M) (2)	80% (M/H) (4)
2	Environment control facilities	Control treatment and disposal	10% (L) (1)	15% (L) (1)
2E	Waste treatment and disposal	Degree of environmental protection	0% (L) (1)	0% (L) (1)
3	3Rs–reduce, reuse and recycling	Recycling rate	0% (L) (1)	0% (L) (1)
3R		Quality of 3R's provisions	5% (L) (1)	10% (L) (1)
Qualitative indicators (Governance factors)				
4U	User inclusivity	User inclusivity	L/M (60%) (2)	L/M (64%) (2)
4P	Provider inclusivity	Provider inclusivity	L/M (69%) (2)	L/M (72%) (2)
6 N	Sound, institutions proactive policies	Adequate national framework	L/M (60%) (2)	L/M (71%) (2)
6L	–	Degree of institutional coherence	L/M (65%) (2)	L/M (73%) (2)

Table 5. Summary of scores obtained through matrix method

Sr. No.	Category	Indicator	Jalandhar city	Himachal Pradesh
Quantitative indicators (Public health, Environmental control, 3R)				
1.1	Public health – Waste collection	Waste collection coverage	2	2
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	3Rs–reduce, reuse and recycling	Recycling rate	1	1
3R		Quality of 3R's provision	1	1
Total Score (Quantitative indicators)			08	10
Maximum score			30	30
Weightage (%)			**26**	**33**
Qualitative indicators (Governance factors)				
4U	User inclusivity	User inclusivity	2	2
4P	Provider inclusivity	provider inclusivity	2	2
6 N	Sound institutions proactive policies	Adequacy of national SWM framework	2	2
6L	–	Degree of institutional coherence	2	2
Total score (Quantitative indicators)			08	08
Maximum score			20	20
Weightage (%)			**40**	**40**
Total score (Overall)			08 + 08 = 16	10 + 08 = 18
Total maximum score			30 + 20 = 50	30 + 20 = 50
Overall weightage (%)			**32**	**36**

The overall results obtained from the quantification of matrix method for Jalandhar city were 32% and 36% for Himachal Pradesh respectively. Hence, it is clearly showed that the quantification score of Jalandhar city was considerably lower than Himachal Pradesh. The results revealed that weight-age acquired from quantitative parameters of 'wasteaware' analysis were reported 26% for Jalandhar city whereas found more for Himachal Pradesh 33%. However, the score for governance factors (quantitative analysis) of Jalandhar and Himachal Pradesh were reported as 40%.

4 Proposals for Strengthening of Municipal Solid Waste Management Services

As a result of urbanization and increasing touristic activities, it is the basic duty of municipal authorities to provide infrastructure and facilities in terms of manpower, machineries, funding to provide effective and efficient services for the adequate and better management of municipal solid waste.

4.1 Hand Cart/Wheel Barrows

For door to door collection of garbage, there should be minimum 40–60 numbers of hand carts in order to meet the primary collection of waste and to improve the collection efficiency of the waste that is the foremost step of the better waste management. The waste sorting and segregation is must at source and at collection stage for efficient management of waste.

4.2 Bins for Segregated Waste Collection

Effective functioning and efficiency of treatment widely varies with the degree of segregation of the waste received at treatment plant. Municipal corporations of Shimla and Dharamshala has already installed underground bins at some urban areas, but still facing the problem in collection of segregated waste. There is a need to provide small dustbins green and blue colour having minimum 10 litre capacities at least at household levels to collect segregated dry waste and wet waste.

4.3 Small Waste Collection Vehicles (E-Rickshaw) for Waste Collection from Litter Bins

Proper collection of solid waste is first important step toward increasing the efficiency of waste management. There is a dire need to float at least 20 more waste collection vehicles (E-Rickshaws) in both of the cities according to the survey of waste management strategy of the cities. The door to door collection of waste from residential and commercial complexes in both the cities should be promoted by municipal authorities in order to avoid littering of waste here and there by the residents.

5 Conclusion

Solid waste management is the globally concerned issue in the present scenario. The study compiled the existing status of municipal solid waste management processes and characterization of waste in Himachal Pradesh. The study revealed that there is dire need to educate every people of the city towards the environmental issues in order to strengthen the aesthetic appearance of environmental and improving health of public. The paper also focussed on the ‘wasteaware’ benchmark indicators and the matrix method system for Himachal Pradesh (Shimla and Dharamshala) and their waste management practices comparative analysis with Jalandhar city. The results clearly

showed the poor performance of environmental control methods including collection and treatment of waste and final disposal of waste in Himachal Pradesh and Jalandhar city. However, the comparative analysis of qualitative and quantitative indicators revealed that Himachal Pradesh exhibits somewhere better results of waste management than that of Jalandhar city. The waste processing facilities should be applicable by the municipal authorities including composting, vermicomposting, reduce derived fuel, vermicomposting, source segregation etc. for the better management of waste. Only inert waste should be disposed in the landfills. However, it is critically observed that there is no such facility of liner, leachate collection and disposal system, gas monitoring facilities, monitoring wells and final cover system for the disposal of solid waste. Open dumping of waste creates annoyance for the health issues of people as well as aesthetic appearance of environment. Hence, open dumps should be avoided and waste should be disposed of in sanitary engineered landfill systems.

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