Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 10, October 2021: 4647-4657

A Comparative Study of Municipal Solid Waste Management in Three Major Cities of Uttarakhand, India

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Abstract: Waste management is a big challenge in emerging countries like India. The purpose of this study is to determine the current condition of waste management in three main cities of Uttarakhand, namely Dehradun, Haridwar, and Rishikesh. Based on municipal solid waste generation, transportation, and disposal in these three important municipalities, a comparative study is conducted. During the current study, it was estimated that Dehradun generates about 350 metric tonnes of waste, Haridwar produces 126 metric tonnes of waste, and Rishikesh produces 60 metric tonnes of waste. After the collection of data, correlation is computed between the population and the waste generation in the three cities and it was concluded that the city with a large population generates maximum waste and poor waste management is found. Among the three cities Dehradun is found to worst in waste management and Rishikesh is much better in managing and handling the waste. There is scope of lot of improvement in all the three cities when it comes to management of waste. The open dumping ground is impacting the people and the environment near the site, thus all three municipalities are having trouble disposing of garbage.

Keywords: Waste Management, Dehradun, Haridwar, Rishikesh, Correlation

Introduction

The term "municipal solid waste" refers to a mixture of household and commercial garbage created by the public at large (Rajkumar *et* al., 2010). Degradable (paper, textiles, food waste, straw, and yard waste), partially degradable (wood, disposable napkins, and sludge), and non-degradable (leather, plastics, rubbers, metals, glass, ash from fuel-burning like coal, briquettes, or woods, dust, and electronic waste) materials constitute municipal solid waste (Jha *et* al., 2011). India is estimated to produce around 62 million tonnes of trash every year, with solid waste averaging 0.4 kg per capita per day (Ramachandran M., 2014). The composition and quantity of MSW were

created to serve as the foundation for planning, designing, and operating the management system. When compared to MSW in Western countries, MSW in India differs significantly in terms of composition and hazardous nature (Gupta S, *et* al., 1998)

Solid waste management is an essential part of the city's infrastructure. As the city takes its position on the global scale, more advanced solid waste management technologies are necessary to alleviate the strains of the world's population's rising migration to cities. It is also necessary for the proper running of social-economic activities. Human actions produce waste, which is inescapable.

Urbanization and high living standards in urban areas have resulted in a rise in the quantity and complexity of garbage created. Rapid population expansion and industrialization damage the urban environment and put a strain on natural resources, making logical and sustainable development more difficult. In most Indian cities, inefficient solid waste management and disposal is a clear source of environmental damage. It is now important to limit the amount of garbage that is disposed of directly to disposal or landfill sites in order to reduce the environmental load. The majority of developed countries use an Integrated Waste Management (IWM) method and Waste Hierarchy to effectively manage their MSW, reducing the need for disposal sites (Tchobanoglous *et* al., 1993)

Current solid waste management techniques, on the other hand, are ineffective and have been shown to harm the micro-and macro-level functioning of global communities and the planet's environment. The uncollected solid waste ends up in drains, blocking drainage systems and generating unhygienic conditions as well as disease breeding grounds. Municipal solid waste has accumulated in every nook and cranny because of poor collection and inadequate conveyance (Bundela *et* al., 2010). Due to the lack of adequate facilities to process and dispose of the increasing volumes of MSW generated every day in metropolitan centers, municipal solid waste management is in a critical phase. The unscientific disposal of MSW has a negative influence on all components of the environment and human health (Gupta *et* al., 2007). There is a need for sustainable management of waste to overcome the issues which have direct or indirect impacts on human health, and the environment.

Material and Methods

Location of the study area: Dehradun is mostly located in the Doon Valley, between the latitudes of 30°01' N and 31°2'N and the longitudes of 77°34' E and 78°18'E. The main city of Dehradun is bordered by Shivalik and the Jaunsar-Bawar region, which is located in the Himalayan foothills. Dehradun has a humid subtropical climate. Depending on the height of the region, it can range from tropical to severe cold. The city is located in Doon Valley, which has significant temperature fluctuations owing to the difference in height. The average annual rainfall in the region is 2,073.3 mm (81.63 in). Dehradun Municipal Corporation, commonly known as Nagar Nigam Dehradun, is the city's municipal government. The municipality has a population of 803,983 and occupies an area of 196.48 km2 (75.86 sq mi) as of 2018.

Haridwar is located at 29.945690oN and 78.164246oE are the latitude and longitude on the right bank of the Ganges River, near the foothills of the Shivalik ranges. It is the state's second-biggest city and the district's largest. Rishikesh is the "Gateway to the Garhwal Himalayas" and the "Yoga Capital of the World," located in the Himalayan foothills of northern India.

Rishikesh is located at 30.103368 °N latitude and 78.294754o E latitude. It is 340 meters above sea level on average (1,120 ft). The town is in the Tehri Garhwal area of Uttarakhand, a northern Indian state. It has a humid subtropical climate. The highest temperature on average is 40 degrees Celsius (104 degrees Fahrenheit). The lowest temperature is 7 degrees Celsius on average.

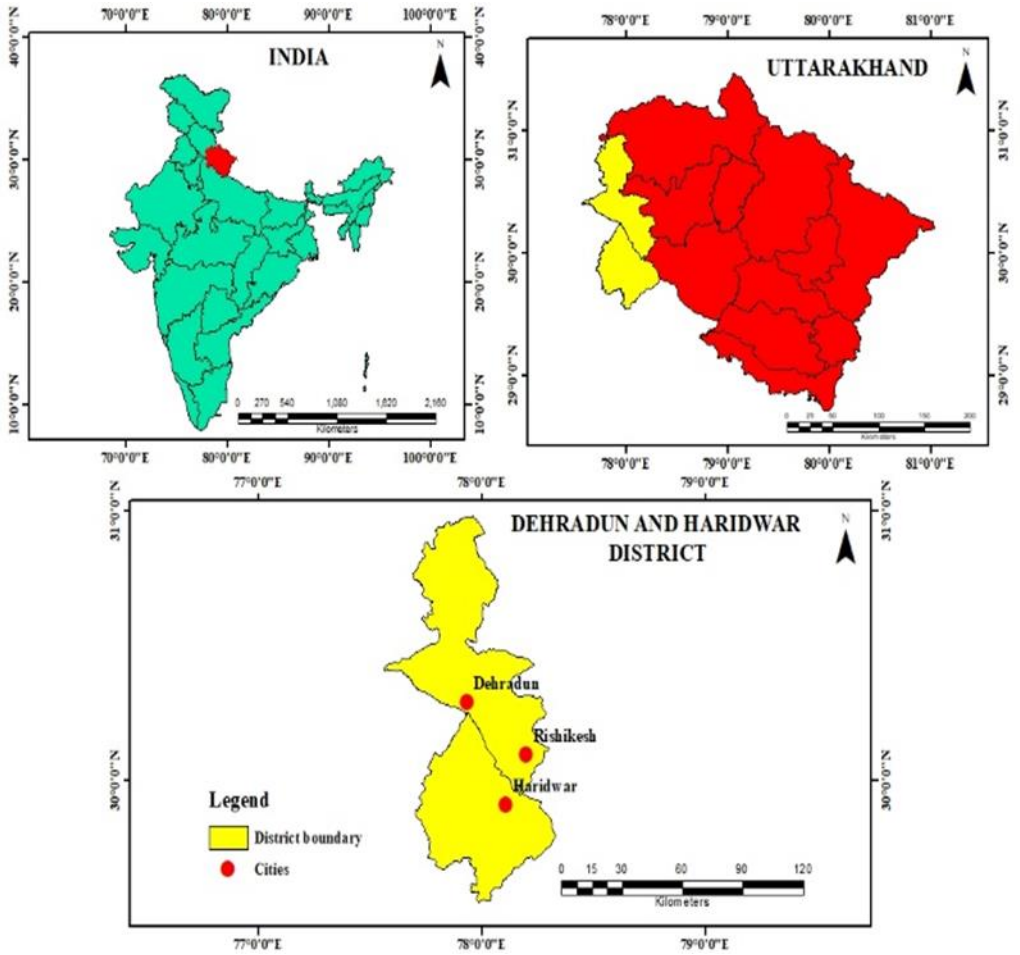

Fig. 1: Map showing the location of the three cities

Objectives

-To assess the amount of municipal solid waste generated in Dehradun, Haridwar, and Rishikesh.

-To analyze the methods employed for municipal solid waste management in these three states of Uttarakhand.

-To suggest suitable measures for improving municipal solid waste management.

Methodology: The study is based on both primary and secondary data. The collection of primary data is done through interviews of the officials and staff of the respective municipality and besides that field visits and observation methods were used. To gather the secondary data various government departments like Nagar Nigam, Haridwar, Nagar Palika Parishad, Rishikesh, and Nagar Nigam, Dehradun was visited. The data collected from the municipal board help to understand the present status of municipal solid waste management in the three municipalities. Various photographs of the dumping ground and other activities like waste collection, transportation were also taken during the survey.

Interviews:

In Haridwar, Rishikesh, and Dehradun, interviews with MSWM system managers were undertaken. Formal and open structured interviews were conducted. The interview help to understand the present status of MSWM in the three major cities.

Direct observation:

The observation method help to identify the reality on the ground. During the visit to study area mainly in Haridwar, it's been noticed that the local people have destroyed the dustbins placed by the municipality, the cooperation from the residents is less which somewhere impacting the management of waste by the municipality, which resulted in heaps of garbage by the roadside or in open space.

Results, Discussion and Recommendations

Waste generation and composition: The population of the three cities i.e. Haridwar, Rishikesh, and Dehradun is 251197, 106320, and 569578 respectively. The waste generation in metric tons per day is 126, 60, and 350. The correlation is computed between the population and the MSW generation and a positive correlation was obtained with a value of 0.99 which tends to perfect a positive relationship between the two variables i.e. the city which is having a greater population is generating more MSW.

Table: 1 Geographical and MSW Generation data of Haridwar, Rishikesh and Dehradun

City	Population (2011 census)	No. of wards	Area in sq.km.	MSW generated (metric ton)/day
Haridwar	251197	60	19.4	126 MT
Rishikesh	106320	40	11.5	60 MT
Dehradun	569578	100	196.5	350 MT

Population source: census report, Government of India (2011)

Table 2 shows the MSW composition in Dehradun, Haridwar, and Rishikesh. The three cities have a significant amount of organic garbage, as well as paper and plastic.

Table 2: Composition of Municipal Solid Waste in Dehradun, Haridwar and Rishikesh

Components	Dehradun (waste in MT/day	Haridwar (waste in MT/day)	Rishikesh (waste in MT/day)
Paper/Cardboard	25	16	6
Plastic	19	12	5
Construction and Demolition	22	9	3
Metal	17	8	1
Glass	26	10	3
Wood	22	13	4

Organic waste/Food Waste	116	43	24
Garden trimming	34	6	11
Other	69	9	3
Total	350 MT	126 MT	60MT

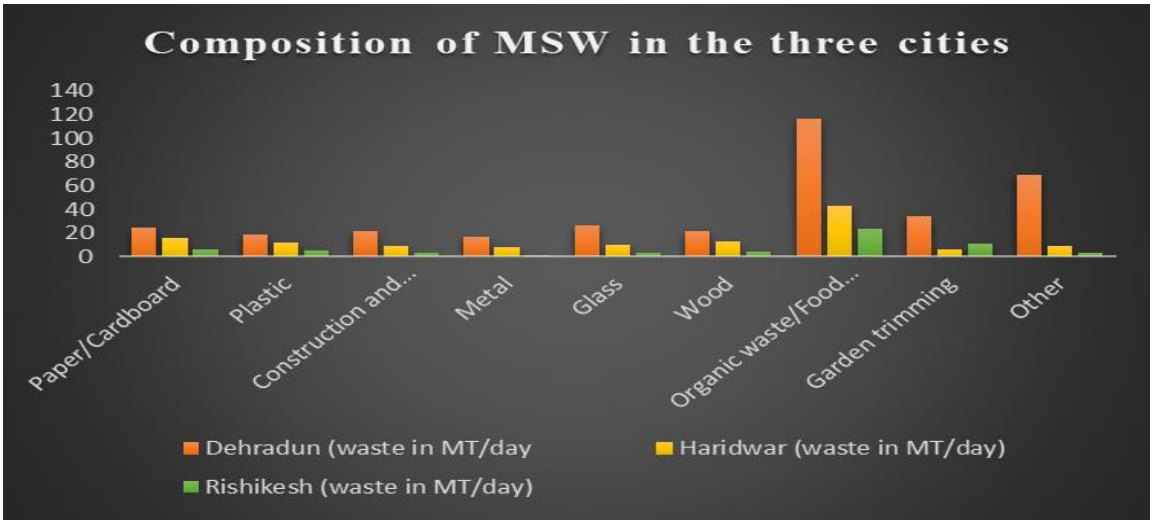

Fig.2: Graph representing the composition of MSW in Dehradun, Haridwar and Rishikesh

Waste segregation: Waste is not segregated at the source of generation: Waste generators in Dehradun and Haridwar are not required to separate waste before disposal. People or door-to-door garbage collectors throw the combined waste into the municipal containers. The waste is mostly thrown in low-lying areas, open areas, and drains. But in Rishikesh, some of the wards practice segregation at source.

Waste collection: Door-to-door garbage collection is only available in a few wards in Dehradun and Haridwar, even waste collection storage bins are not available in every area in these two cities. The Residents of the city dump MSW outside their homes, where Nagar Nigam sweepers gather the garbage with handcarts and deposit it into containers or along the roadside (open dump). Except in a few places, there are no secondary waste storage facilities: There are only a few containers accessible for secondary MSW storage. The locations where containers are stored are rusty or

broken. In the lack of a secondary storage facility for MSW, the garbage is dumped anywhere nearby, including drains, vacant plots, street corners, low-lying regions, and other open spaces. Comparatively, Rishikesh has a far better door-to-door collection rate with an adequate number of dustbins covering the entire city.

Fig. 3: Plates representing the present status of waste management in Haridwar and Dehradun

Waste transportation: The table below depicts the types of vehicles and the number of vehicles available with the municipality to serve the area. The number of vehicles available for waste management in Dehradun is 427 in number. Haridwar and Rishikesh have 541 and 205 vehicles respectively for the management of waste.

The process of transfer and transportation is divided into two parts: (i) transferring garbage from the smaller collection truck to the bigger transport equipment, and (ii) transporting the waste to a processing or disposal location, frequently across considerable distances. During the transportation of waste, the transporting vehicles are not covered which results in spilling of the garbage on roads as well as causes harm to the environment. Manual loading and offloading of trash take place. Aside from that, there is no monitoring mechanism in place for DMC's garbage collection and delivery vehicles.

Table 2: Infrastructure availability of the three municipalities.

S.N.	CITY	TYPE OF VEHICLES	NUMBER OF VEHICLES
1	**DEHRADUN MUNICIPALITY**	**1) Mini collection Trucks**	100
		2) Bulk Waste collection Trucks	5
		3) Wheel Barrow	0

		4) Manual Rickshaw	38
		5) Battery operated Rickshaw	0
		6) Auto Three wheeler	2
		7) Hydraulic Tata Ace/ Tipper 1.5 cu.m.	6
		8) Hadraulic Truck 6 cu.m.	4
		9) JCB	1
		10) Bob Cat	0
		11) Any other	271
		Total number of transport	427
2	**HARIDWAR MUNICIPALITY**		
		1) Mini collection Trucks	99
		2) Bulk Waste collection Trucks	14
		3) Wheel Barrow	360
		4) Manual Rickshaw	0
		5) Battery Operated Rickshaw	58
		6) **Auto Three wheeler**	0
		7) Hydraulic Tata Ace/ Tipper 1.5 cu.m.	0
		8) Hydraulic Truck 6 cu.m.	3
		9) JCB	3
		10) Bob Cat	1
		11) Any other	3
		Total number of transport	541
3	**RISHIKESH MUNICIPALITY**	**1) Wheel Barrow**	140 (Push Cart)
		2) Manual Rickshaw	28
		3) Battery Operated Rickshaw	0
		4) Auto Three Viler	0
		5) Hydraulic Tata Ace/ Tipper 1.5 cu.m.	29
		6) Hydraulic Truck 6 cu.m.	2
		7) JCB	2
		8) Bob Cat	1

	9) Tractor Trolly	3
	Total number of transport	205

Waste Treatment and Disposal: Disposal is the final phase of the MSW management system. Today, the ultimate fate of all solid wastes is landfilling or uncontrolled dumping, whether they are household wastes, the collected waste is delivered straight to the Landfill site. Dehradun delivers 95% of the waste to landfill, similarly Haridwar perform open dumping with 62% of waste. The waste sent to landfill by Rishikesh is the least i.e. 59% respectively. Among the three cities composting, recycling, and conversion of waste to energy is performed largely by Haridwar. On the other hand the other two cities (i.e. Dehradun and Rishikesh) lack in recycling and waste to energy generation but composting of waste is done to some extent.

Municipal Solid Waste Management Practices in the three cities

Landfilling: Landfilling is the process of dumping garbage into the ground. For landfilling, proper procedures should be followed, such as coating the base with a protective layer, selecting a low groundwater level location, and so on. This method necessitates the use of skilled labour. Construction of horizontal wells in landfills carrying municipal solid waste reduces leachate levels in China (Hu *et* al., 2020). A model based on physical, chemical, and biological processes regulates Hg emissions from landfills (Tao *et* al., 2020).

Compositing: Organic wastes are isolated from other wastes and left in a pit to decay for a long time by bacteria. The compost is then turned into nutrient-rich manure for the plants. These manures improve the fertility of the soil. The fertility of the soil is improved by composting using biological techniques. The vermicomposting technology has a low environmental impact and improves soil nutrient content (Bhat *et* al., 2020).

Incineration: Incineration is the process of burning garbage at a high temperature. Filters are used to prevent air pollution (which is created by the burning of garbage). Direct incineration without anaerobic digestion was found to be a more sustainable option for dealing with sludge (Hao *et* al., 2020). The technology of a coal power plant combined with a waste incineration method was deemed a promising technology for fossil fuel conservation and waste disposal (Ye *et* al., 2020)

Recycling: Collecting waste from various locations and sorting it into categories based on the nature of the products to be recycled. Municipal and construction solid waste were recycled and used to make very environmentally friendly geopolymer composites (Tang, Tam & Xue, 2020).

Waste to energy: The process of converting garbage into energy in the form of electricity or heat is known as waste-to-energy. Waste-to-energy (WtE) technologies like pyrolysis, gasification, incineration, and bio-methanation can transform MSW into useable energy (electricity and heat) in a safe and environmentally beneficial manner (Malav *et* al., 2020).

S.N.	**Activity/Practices**	**Haridwar**	**Rishikesh**	**Dehradun**
1.	**Landfilling**	Open duming (uncontrolled manner)	Limited to landfill sites	Open duming (uncontrolled manner)

2.	**Composting**	20% is treated for making compost	9% is treated for making compost	7% is treated for making compost
3.	**Incineration**	NO	NO	NO
4.	**Recycling**	15%	NO	NO
5.	**Collection**	80%	90%	85%
6.	**Waste to Energy**	30%	NO	NO

Discussion

After the collection and analysis of data it is computed that among the three cities Rishikesh is better in management of the waste when it comes to collection, segregation, transportation, disposal and treatment of waste. On the other hand, Dehradun which is the capital city is found worst in waste management, a lot of improvement is required both at the municipal level as well as people participation level as during the survey it is observed that the awareness level of people regarding waste handling and management is quite low. Even in Haridwar the people are not egger to support the municipality and private collector. If dustbins are placed in market area, the local residents or the shopkeepers destroy them. There is scope of lot more improvement in waste management in all the three cities. The results will be fruitful only when municipality, private collector and people will work hand in hand to share the responsibility.

Recommendations

- First and foremost, authorities should conduct an in-depth study of MSW features in the three cities in order to obtain relevant data or details on physical, chemical, and biological properties of MSW. The amount of MSW created in the city will aid decision-makers in determining the best practises and number of bins to install based on garbage generation.
- Three types of dustbins, each with a distinctive colour, should be installed in public and crowded areas: one for paper and cardboard, one for plastic bottles and recyclables, and one for other garbage. More focus should be placed on kabadiwalas, who collect domestic waste such as papers, plastics, metals, leather, and other materials in exchange for money. This reduces the amount of rubbish that needs to be hauled to the plant while also encouraging individuals to sort their trash into separate bins.
- Household waste should be collected in separate chamber vehicles for dry and wet waste by door-to-door waste collectors.
- When dealing with solid waste, employees should wear uniforms, gloves, and masks throughout working hours.
- The solid waste processing facility should be equipped with all necessary equipment as soon as feasible so that it can effectively and efficiently manage and treat the garbage for at least 40 years while also producing valuable resources.

Conclusion

Municipal Solid Waste Management is generally the duty of local governments. Technical challenges in waste collection, transportation, and disposal, a lack of public awareness and skilled human

resources, economic barriers to research and development of new technologies, traditional methods used in waste segregation by landfill scavengers, waste smuggling, high littering rates, illegal dumping of wastes, little to no knowledge about waste recycling, and difficult local architecture for collection are just a few of the issues. If public awareness of sustainable consumerism, waste segregation, and recyclable/non-recyclable/hazardous trash is spread, it may

aid in the management of the solid waste collection process to some extent. The current waste management approach's fundamental flaw is that we do not have a sustainable waste management strategy for our separate communities. Policies are made at the national and regional levels, but actions must be implemented at the local level: public engagement and inclusion are critical for systemic change. Existing Solid Waste Management practices are economically unsustainable. As the in-depth analysis of Dehradun, Haridwar city's MSW management reveals, there are numerous limitations in efficiently handling and processing the city's MSW. Currently, the city generates less SW than other metro cities, but annual waste creation increases as the population grows and people's attitudes toward garbage change. In summation, there is a dearth of holistic or multi-dimensional approaches in waste management systems.

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