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Generation and composition analysis of municipal solid waste (MSW) in District Shopian Kashmir, J & K, India

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Abstract

The present investigation is an attempt to explore the composition, characteristics, and generation rate of municipal solid waste in the Shopian (J&K) by selecting five different sites. The study revealed that the average residential municipal waste generation rates differed among sites. Daily, Site II recorded highest amount of waste generation 170.3 kg/day and minimum of 48.56 kg/day was recorded at SV. According to the seasons, summer has the biggest amount of daily waste generation 320.3 kg/day to a minimum of 98.3 kg in winter. The rate of waste generation per capita varied, ranging from 0.521 kg/capita/day (SII) to 0.3455 kg/capita/day (SV). The per capita waste generation rate was observed to change seasonally, ranging from 0.6589 kg/capita/day in the summer to 0.306 kg/capita/day in the winter. The average municipal solid waste composition of municipalities at different sites, based on the geographical scale: SI, SII, SIII, SIV, and SV. SII had the highest food waste proportion, followed by SI and the other locations. The waste fractions of paper and cardboard were greater at SIV, whereas the rest of the fractions followed a similar trend across sites. The % by weight (composition) of municipal garbage varied insignificantly among seasons (F= 2.33E-06, P=1) and sites (F= 9.15E-08, P=1), according to an analysis of variance test. The study also revealed that the proportion of flammable material in municipal solid trash ranged from 95% at SII to 83 % at SIII, whereas the percentage of non-combustible material in municipal solid waste ranged from 18% at SIII to 5% at SII. Seasonally, the combustible material percentage of the municipal solid waste ranged from 89 % in spring to 88% in all other seasons. Analysis of variance showed insignificant variation in % of combustible and non-combustible material content across different seasons (F=0.0328, P=0.895) and significant across sites (F=3.76, P=0.003).

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Introduction

Municipal solid waste (MSW) is a serious issue in the world's urbanised regions, which is growing at a faster pace than the rate of urbanization (Kumar and Agrawal, 2020). As a result of inefficient energy and resource use, human activities create municipal solid waste (Laohalidanond *et al.*, 2015). In municipal waste trash, recyclables (paper, glass, plastics, metals), biodegradable organics (food waste, vegetables, and fruits), poisonous materials (medicines, paints, pesticides, and batteries), and hazardous chemicals (syringes, blood-stained cotton, used sanitary napkins) are all found (Gupta *et al.,* 2015; Kolekar *et al.,* 2016). With a population of 1.21 billion people, India's cities account for 31.16 % of the country's population, or 337 million people (Registrar General, 2011). The amount of waste produced per person in India has increased considerably, from 0.26 kg per day to 0.85 kg per day (Duttaand Jinsart, 2020). India generates around 143, 449 metric tonnes of waste, of which 111, 000 metric tonnes are collected and 35, 602 metric tonnes are handled (Kumar *et al.*, 2017). The amount of solid trash produced is determined by economic status, business operations, eating habits, as well as geographic and meteorological factors (Kumar and Agrawal, 2020). India now generates around 147 million tonnes of trash per year, with 300 million tonnes predicted by 2047 (CPCB, 2016). The composition of municipal waste has a big influence on waste management practices (Sharma and Agrawal, 2020). Indian municipal solid waste (5 percent) typically contain food trash and grass clippings (50 percent), building and demolition debris (29 percent), glass/metal (5 percent), plastic (4 percent), cloth (7 percent), and paper (5 percent) (Ahluwalia and Patel, 2018). In India, the land area required for waste dumping has climbed from 1200 square kilometers in 2012 to 1400 square kilometers in 2021 and is expected to reach 1800 square kilometers in 2051 (Joshi and Ahmed, 2016). The quantity of municipal solid waste generated by 1018 wards in Jammu and Kashmir is 1489 metric tonnes per day (MoHUA, 2020). All houses in 137 wards of Jammu and Kashmir have embraced source segregation, and 809 wards have successfully implemented 100 percent door-to-door collection under the Swachh Bharat Mission (MoHUA, 2020). Under the Swachh Bharat Mission, Jammu and Kashmir process 16 percent of all garbage generated (MoHUA, 2020).

Jammu and Kashmir are some of India's fastest-growing states, with good economic growth, population boom, urbanization, industrialization, and a scarcity of resources that has resulted in massive amounts of municipal solid trash. Developing areas with a mountainous topography, such as Jammu and Kashmir, confront significant issues in solid waste management due to their very sensitive ecology and tough terrain. Solid waste issues in the mountainous terrain have severe cascading impacts on the lower valley. Solid waste is often the most significant threat to the fragile ecosystems of mountainous regions (Jain, 1994). Furthermore, the inability of the general public and local authorities to follow the rules and legislation issued by the federal and state governments has put the waste management dilemma and environmental deterioration in jeopardy. Shopian district is an emerging district/town in Jammu and Kashmir, India located between Latitude: 33° 43' 2.03" N and Longitude: 74° 50' 2.87" E at an elevation of 2146 meters above sea level in the south of Kashmir valley. Solid waste management is the responsibility of the Shopian Municipal Committee. Municipal solid waste mismanagement is attributed to a lack of financial and human resources, as well as organizational inefficiencies in adhering to established standards and legislation within municipal organizations. Investigation of the composition, characterization, and generation rate of municipal solid waste distribution in the Kashmir Himalayan region and particular Shopian district appears to be a neglected area of research. A small number of studies are available on municipal solid waste, the majority of them are restricted to the Srinagar city at the selected sites while not considering newly established districts. The reports accessible on the municipal solid waste in Kashmir have been reported by Ahmed and Bhat (2007) and Akhter and Najar (2016). On the other hand, no scientific assessments on solid waste generation and composition have been done so far, which is the most significant impediment to solid waste management. The present investigation is an attempt to explore the composition, characteristics, and generation rate of municipal solid waste in the Shopian district. So, far no proper assessment on municipal solid waste is done before suggesting and implementing strategies. Therefore, the present study will help to overcome the difficulty of using proper protocols and techniques for the rapid and safe disposal of waste.

Materials and methods

Solid waste samples were collected from dustbins and open dumping sites located at five different wards of the Shopian Municipal Committee from 2019 and 2020. Every month, at the end of the day, samples were collected from dustbins and dumping sites and placed in 5-kilogram polybags. Weighing of waste was carried out by using a digital balance/spring balance to estimate the amount of solid waste generated. The compositional study was carried out after the total waste generated at each location was estimated independently. Spreading, hand sorting, and segregation of samples on the ground into distinct waste components were used to determine the mean composition of waste. The total weight of each waste component/constituent was recorded after each component/constituent was weighed individually. Finally, the components identified were classified as biodegradable or non-biodegradable (Gaxiola, 1995; Rampal *et al.*, 2002; Benitez *et al.*, 2003).

1. Combustible and non-combustible substances:
The weight percent of combustible and non-combustible substances were computed as follows. Standard methods were followed (Ahmed Bhat, 2007; US EPA, 2008).

- Combustible material (%) = Plastic (%) + Paper (%) + Textile (%)
- Incombustible material (%) = Metal (%) + Glass (%)

2. Net weight composition (%) of constituents was calculated by using formula as:

$$\text{Net weight composition (\%)} = \frac{\text{Weight of constituent of solid waste}}{\text{Total weight of constituents}} \times 100$$

3. A weight–volume analysis was used to determine the generation rate (GR, the weight of waste produced by a person per unit time).

$$\text{GR} = \frac{\text{Weight of Solid Waste (g)}}{\text{Population} * \text{Duration (day)}}$$

The purpose of GR measurement was to collect information that may be used to calculate the overall amount of trash that has to be handled. Weight volume data obtained by weighing and measuring each load would almost certainly provide further information on the density of different types of solid waste at a specific place. The data was calculated as a weighted average for the entire municipality, based on the population of various areas.

4. Net weight (kg) or dried weight (kg) was also calculated by using the above formula as;

$$\text{Net weight (kg)} = W_w - \frac{(\text{Moisture content} \times W_w)}{100}$$

Results and discussion

Consumer trends, eating habits, traditional practices of people, lifestyles, climate, topography, and economic status all influence the characteristics of MSW collected from every area. With the increased usage of packaging materials and plastics, the composition of MSW is changing. Domestic waste accounts for over 70%–80% of total MSW produced, according to estimates. Non-household trash accounts for 20% of non-household waste in the studied municipality, which has a significant scale inter-and intra-district mobility of inhabitants for economic and commercial operations. Below are some details on the computation of per capita MSW generation at each location within the Shopian municipality. Based on per capita per day generation and total population (26 626 people), the total quantity of municipal solid waste produced within the municipal limits of Shopian is approximately 14000 kg/day (14 tons/day).

The average residential municipal waste generation rates differed among sites (Figure 1). Daily, Site II recorded highest amount of waste generation 170.3 kg/day and minimum of 48.56 kg/day was recorded at SV. According to the seasons, summer has the biggest amount of daily waste generation 320.3 kg/day to a minimum of 98.3 kg in winter (Figure 2). The rate of waste generation per capita varied, ranging from 0.521 kg/capita/day (SII) to 0.3455 kg/capita/day (SV) (Figure 3). SII has greater per capita waste production, which is due to the area's rapid urban expansion and economic development, which has accelerated consumption rates, resulting in higher waste generation rates. The per capita waste generation rate was observed to change seasonally, ranging from 0.6589 kg/capita/day in the summer to 0.306 kg/capita/day in the winter (Figure 4).

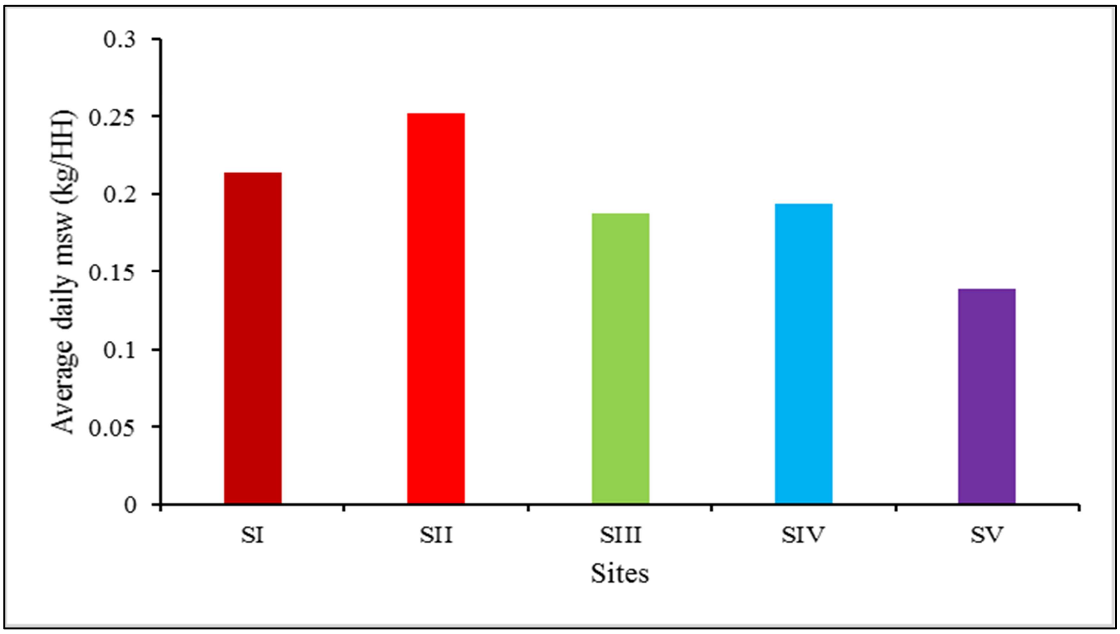

Fig. 1. The average household (HH) municipal waste generation rate at different sites

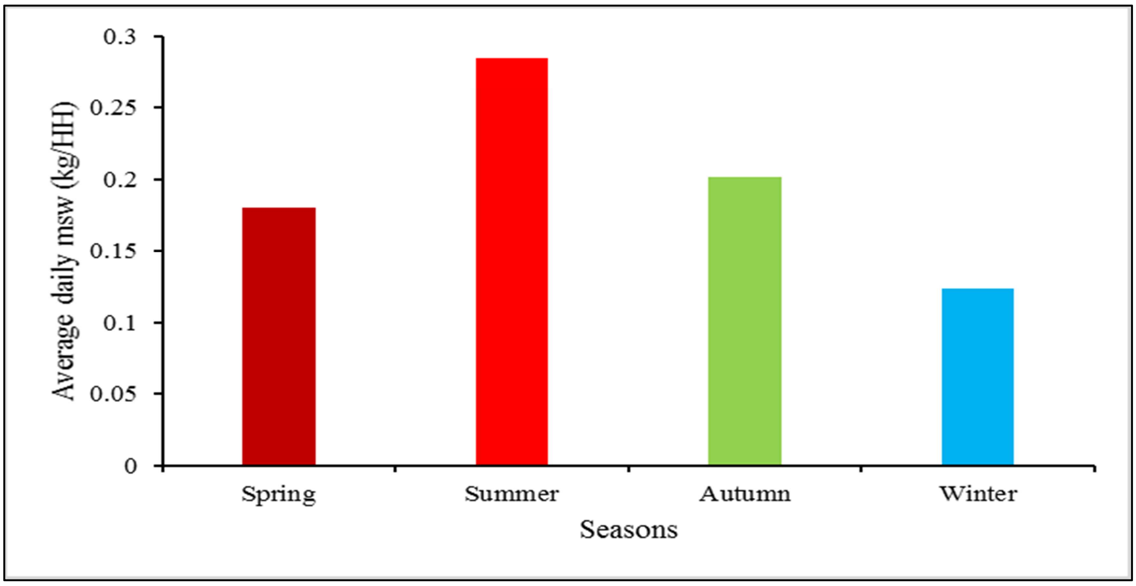

Fig. 2. The average household (HH) municipal waste generation rate in different seasons.

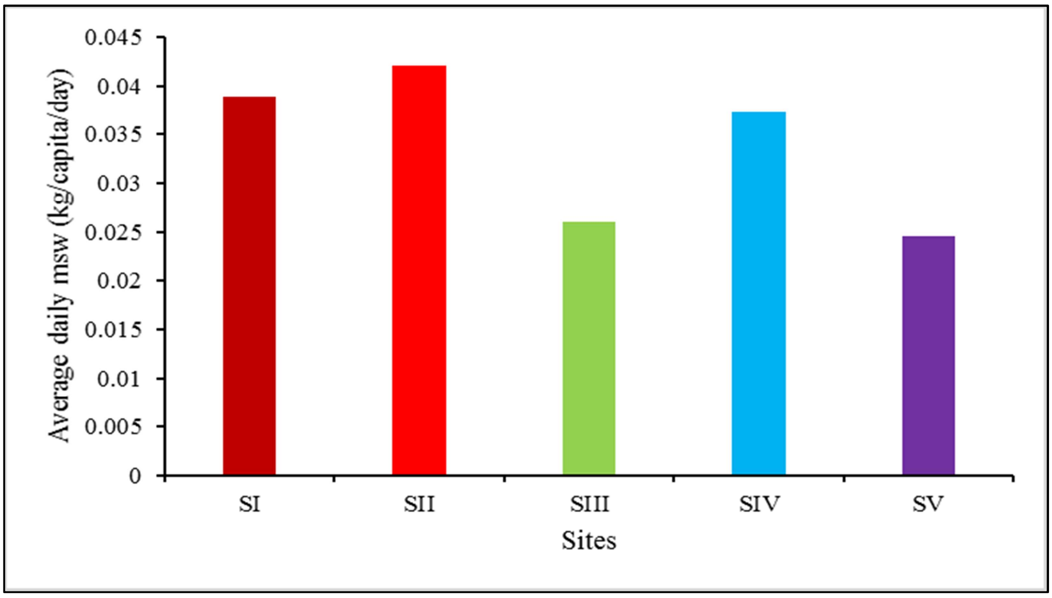

Fig. 3. The average daily per capita (kg) municipal waste generation rate at different sites

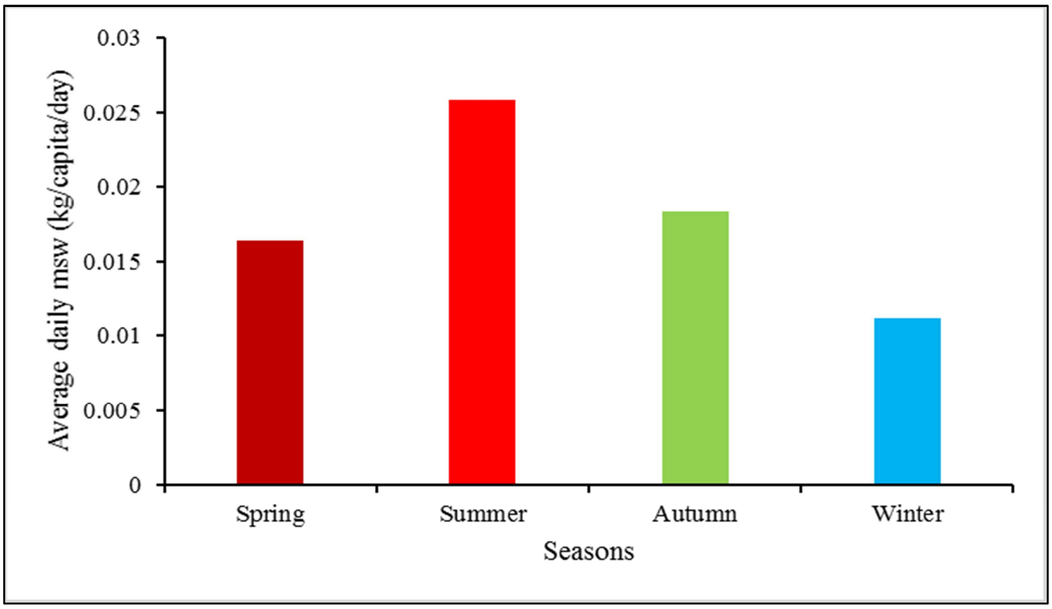

Fig. 4. The average daily per capita (kg) municipal waste generation rate in different seasons.

According to the findings, the weight and volume of municipal solid waste are roughly 15% more in the summer than in the winter. According to the findings of this study, the average per capita waste production on a geographical scale is 0.3694 kg/capita/day, and the average per capita waste production on a temporal scale is 0.390428 kg/capita/day. The average daily waste created per person is 0.85 kilograms, according to the CPCB (Dutta and Jinsart, 2020). Even though several studies on waste characterization have been published, there are only a few studies on seasonal MSW fluctuations. In 2005, the MSW generation of Srinagar city was 428 Mt/day, and prior research has revealed that MSW output has been increasing. The explanation for this might be that the town's economy has grown as a consequence of greater population and higher incomes, which has raised MSW generation rates, while people's lifestyles and eating habits have changed dramatically in recent years (TPOK, 2019).

The average composition of household waste of the 5 sites in the 11 major waste categories is shown in Figure 5. Food waste was the biggest waste fraction (33 %), followed by cardboard (14 %), plastics (10 %), paper products (10 %), textile rags (8 %), metals (5 %), bones (6 %), wooden chips (7 %), and glass (7 %), according to the waste composition analysis. Rubber, leather, and inert each accounted for less than 1% of the total. The high food waste concentration shows the necessity for regular collection and disposal, as well as promising organic waste resource recovery opportunities. Plastic, paper goods, cardboard, metal, glass, rubber, leather, and textiles made up on average 7.2 % of all reusable and recyclable materials.

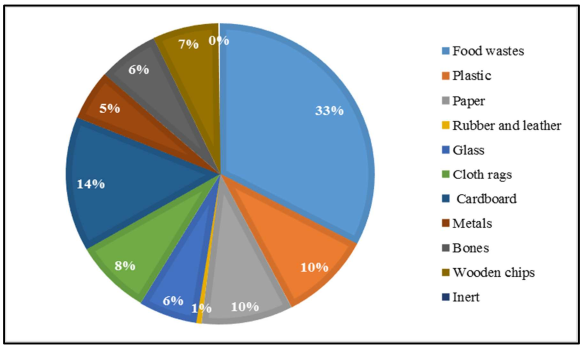

Fig. 5. Composition of municipal solid waste (%) at the 5 sites of the Shopian Municipality.

It's also worth noting that the mix of municipal solid waste differed significantly across seasons. Figure 6 depicts the average municipal solid waste composition of municipalities throughout the year, including spring, summer, autumn, and winter. In the winter and spring seasons, the food waste portion was larger than in the summer and autumn seasons. During the summer, the cardboard waste portion was greater. Other fractions, on the other hand, displayed a more or less consistent trend throughout seasons. The average municipal solid waste composition of municipalities at different sites, based on the geographical scale: SI, SII, SIII, SIV, and SV.SII had the highest food waste proportion, followed by SI and the other locations. The waste fractions of paper and cardboard were greater at SIV, whereas the rest of the fractions followed a similar trend across sites (Figure 7). The % by weight (composition) of municipal garbage varied insignificantly among seasons (F= 2.33E-06, P=1) and sites (F= 9.15E-08, P=1), according to an analysis of variance test.

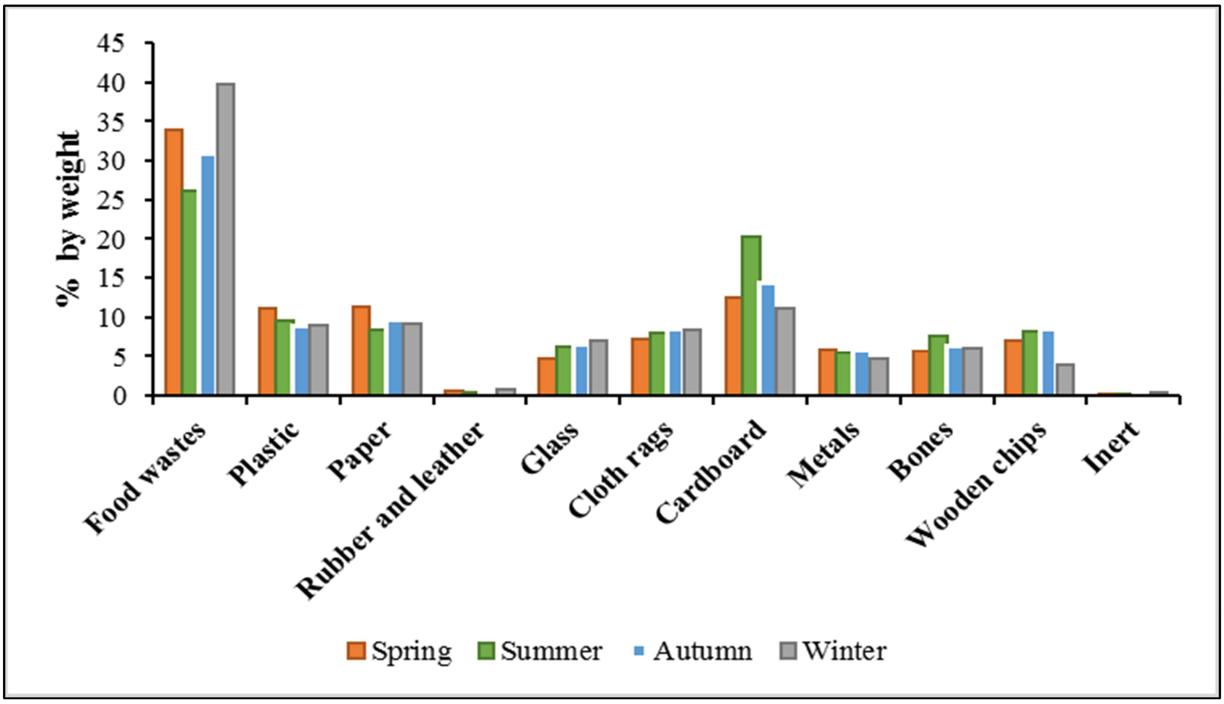

Fig. 6. Composition of municipal solid waste in different seasons (%)

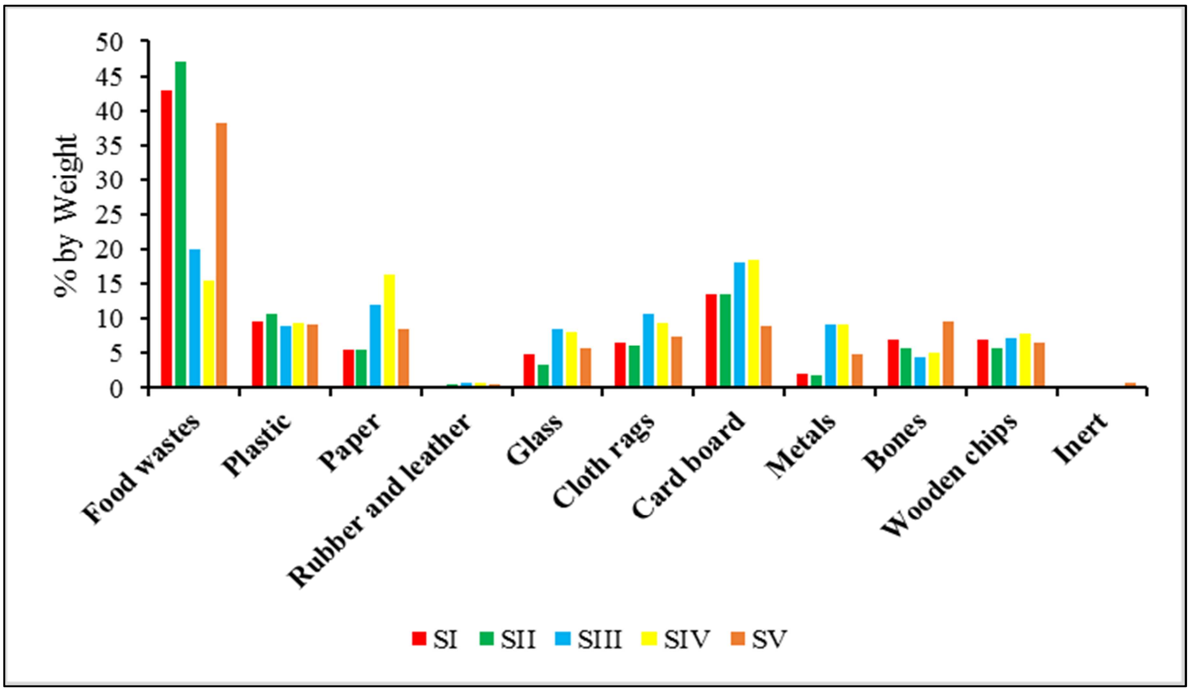

Fig. 7. Composition of municipal solid waste at different sites (%)

The types and volumes of waste differ by city, and these differences are attributable in large part to the impact of consumption patterns, waste production index, demographic composition, socioeconomic and cultural level, and in large part to the impact of consumption patterns (Berneche-Perez *et al.,* 2001; Buenrostro *et al.,* 2001). The features of municipal solid waste found in the Shopian Municipality were similar to those found in previous studies conducted across India (Annepu, 2012; Joshi and Ahmed, 2016; Ahluwalia and Patel, 2018). In India, around 40-60% of municipal solid waste is biodegradable, 30-50% is inert waste, and 10% to 30% is recyclable (Annepu, 2012; Gupta *et al.* 2015; Joshi and Ahmed, 2016). In the current study, the proportion of compostable, recyclable, and inert waste was roughly 66 %, recyclable %, and inert 1 %. Food waste dominates the composition of municipal waste, according to the data (mixed).

The percentage of combustible and non-combustible material in municipal solid waste is one of the most essential properties. The proportion of flammable material in municipal solid trash ranged from 95% at SII to 83 percent at SIII, whereas the percentage of non-combustible material in municipal solid waste ranged from 18% at SIII to 5% at SII Seasonally, the combustible material percentage of the municipal solid waste ranged from 89 % in spring to 88%in all other seasons. The graph (Figure 9 and 10) shows the comparison of the Combustible and Non-combustible proportion (%) of the waste types at different sites and across seasons. Analysis of variance showed insignificant variation in % of combustible and non-combustible material content across different seasons (F=0.0328, P=0.895) and significant across sites (F=3.76, P=0.003.

The combustible content of the municipal solid waste collected for this investigation ranged from 95 % at SII to 83% at SIII, and 89 % in spring to 88% in all other seasons. One of the most critical factors in defining a material's burning properties is its combustible content. The higher amount of combustible content provides an opportunity for energy recovery and generation. It has been reported that 60% of municipal solid waste is carbonaceous, comprising of biodegradable material that can be converted into methane or incinerated to generate utilizable energy (Abbasi, 2018).

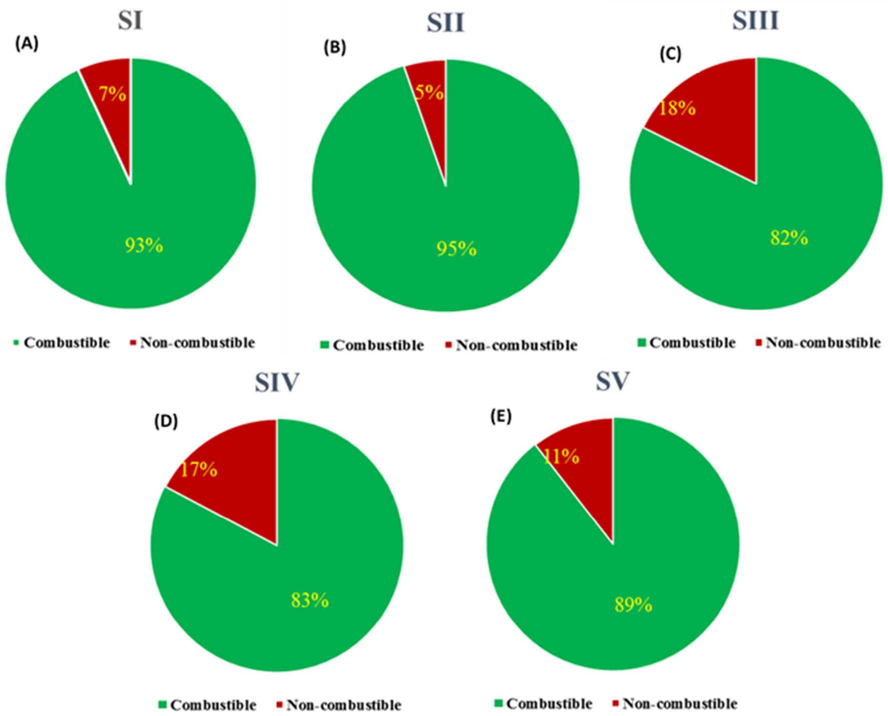

Fig. 8. Composition of (%) combustible and non-combustible material in municipal solid waste at five different sites.

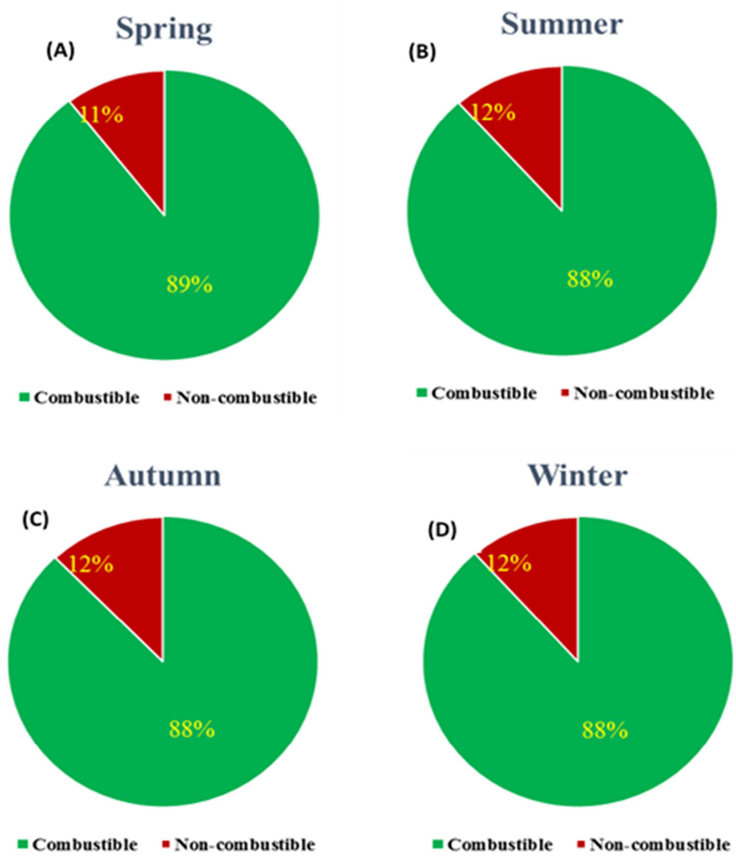

Fig. 9. Composition of (%) combustible and non-combustible material in municipal solid waste across different seasons.

Municipal solid waste also comprises several recyclable components like glass and metal scraps, which can be reused or recycled, thereby helping in achieving energy conservation (Moyna, 2012; Abbasi, 2018). Incineration is the most common and prevalent technology being used for the generation of energy from municipal solid waste (Chen and Christensen, 2010). Incineration techniques have the advantage of reducing the volume of municipal solid waste from 70-90% for landfilling and killing disease-causing organisms (pathogens) (Zhang, 2012).

Conclusion

The study divulges that the solid waste consists of a large proportion of biodegradable and recyclable materials. If the sustainable waste management methods such as composting, vermicomposting and recycling are adopted; there is a greater eventuality of reducing substantial quantity of waste generated in the area. Further the quantity of non-biodegradable and non-recyclable waste like polythene and Styrofoam can be reduced by banning their use within the area by making and implementing appropriate legislative provisions.

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