**Analyzing Sikkim’s Waste Management Trends (2016-2024)**

**Sikkim** is the least populous state and the second-smallest state by area, located in the north-eastern part of Bharat. With increasing urbanization, the generation of municipal solid waste (MSW) has witnessed significant shifts over the years, requiring detailed monitoring and analysis. This assignment focuses on evaluating the trends in solid waste management across Sikkim from 2016–17 to 2023–24, both at the **state-wide** and at **urban local body (ULB)** levels.

​The effective management of municipal solid waste (MSW) is a critical component of sustainable urban governance, particularly in ecologically sensitive regions such as Sikkim. The state's unique topography, characterized by steep terrains and dispersed settlements, poses significant challenges to the implementation of efficient waste management systems. In response to these challenges, the Government of Sikkim has undertaken various initiatives to enhance waste management practices, aligning with the Solid Waste Management Rules, 2016, and other relevant environmental regulations. ​

This assignment aims to analyze the trends and efficacy of waste management strategies in Sikkim from 2016-17 to 2023-24. The study is bifurcated into two primary sections:​

1. **State-Level Analysis (2016-17 to 2023-24):** This section evaluates the temporal progression of waste management metrics across Sikkim. Key performance indicators such as growth rate in waste generation, collection efficiency, per capita waste generation, landfill dependency, and processing focus are examined. The analysis provides insights into the state's capacity to manage increasing waste volumes and the effectiveness of implemented policies over the specified period.​
2. **Urban Local Bodies (ULBs) Assessment:** The second section delves into a granular analysis of waste management practices across individual ULBs in Sikkim in the year 2023-24. By examining parameters like unmanaged waste volumes, collection-processing gaps, and per capita waste generation, the study identifies disparities in waste management efficacy among different ULBs. This assessment is crucial for understanding localized challenges and tailoring interventions accordingly.

The findings from this comprehensive analysis inform policymakers, urban planners, and environmental stakeholders about the current state of waste management in Sikkim. By identifying areas of success and those requiring improvement, the study contributes to the development of more effective, sustainable, and context-specific waste management strategies, thereby enhancing environmental governance and public health outcomes in the region.

**Data Compilation and Analysis**

**Key components and their formulae**

**A table with numbers and symbols

AI-generated content may be incorrect.**

2.1 Waste Management Efficiency (%)

This metric measures the proportion of total waste that is either processed or safely landfilled.

Formula: Efficiency (%) = ((Processed Waste + Landfilled Waste) / Total Waste Generated) × 100

2.2 Per Capita Waste Generation (kg/day)

This metric assesses the average amount of waste generated per person per day.

Formula: Per Capita Waste = (Waste Generated (TPD) × 1000) / Population

2.3 Landfill Dependency vs. Processing Focus (%)

Formula for Landfill Dependency: Landfill Dependency (%) = (Waste Landfilled / Total Waste Generated) × 100

Formula for Processing Focus: Processing Focus (%) = (Waste Processed / Total Waste Generated) × 100

2.4 Collection-Processing Gap (TPD)

This metric measures the difference between waste collected and the sum of waste processed and landfilled.

Formula: Collection-Processing Gap = Waste Collected - (Waste Processed + Waste Landfilled)

Unmanaged Waste (TPD) = Waste generated - (Waste Processed + Waste Landfilled)

**Trend Analysis of Sikkim’s Waste Management (2016–2024)**

**1**. Waste Generation & Growth Rate:

* Overall Insight
  + Waste Generation from 2016-2024
    - Average Waste Generated = 71.88875 TPD
    - Maximum Waste Generated = 76.04 TPD (2016-17)
    - Minimum Waste Generated = 65.5 TPD (2021-22)
  + Growth Rate from 2016 – 2024
    - Average Growth Rate = -1.144737058 %
    - Maximum Growth Rate = 5.114503817 % (2022-23)
    - Minimum Growth Rate = -8.901251739 % (2021-22)
* Overall Waste Generation shows moderate fluctuation, with a slight decline from 76.04 TPD in 2016–17 to 69.68 TPD in 2023–24.
* The growth rate fluctuated over the years, with notable decreases in 2017–18 (−3.55%) and 2021–22 (−8.90%), and increases in 2022–23 (5.11%) and 2023–24 (1.21%). This could be attributed to population stabilization, improved waste minimization strategies, or better segregation practices.
* 2022–23 and 2023–24 witnessed a rebound with a slight positive growth rate of 5.11% and 1.2%, respectively.

2. Efficiency (%):

* Overall Insight
  + Average Efficiency: 93.5528058 %
  + Maximum Efficiency: 100 % (2020 onwards)
  + Minimum Efficiency: 79.76547587 % (2017-18)
* Efficiency remained high throughout, peaking at 100% from 2019–20 onwards, which indicates that all generated waste was either processed or landfilled, leaving no unmanaged waste.
* The sharp increase from 79.77% (2017–18) to 99.86% (2019–20) suggests significant infrastructure improvements or better waste tracking and reporting.

3. Per Capita Waste Generation:

* Per capita waste generation remained relatively stable, ranging from 0.43 to 0.48 kg/day.
* The trend is stable, indicating that individual waste generation habits have not drastically changed, even though total population decreased slightly over time.

4. Landfill Dependency (%):

* Consistently high till 2019–20 (over 68–83%), then a notable decline to 47.5% in 2023–24.
* This trend reveals that Sikkim is gradually shifting away from landfilling towards processing and resource recovery methods—an encouraging move for environmental sustainability.
* Landfill dependency decreased significantly from 68.45% in 2016–17 to 47.52% in 2023–24.

5. Processing Focus (%):

* A clear upward trend is seen: from 14.53% in 2016–17 to 52.48% in 2023–24.
* The state has made substantial progress in increasing waste processing capacity, likely through composting, segregation, or bioconversion facilities.

6. Collection-Processing Gap:

* From a small gap of 4.5 TPD in 2017–18, the value has narrowed down to zero from 2020–21 onwards.
* This implies improved synchronization between waste collection and its subsequent processing or disposal—critical for reducing dumping and overflow.

Insights

At the ULB level, Gangtok Municipal Corporation (GMC) stands out, generating approximately 49 TPD of waste, accounting for nearly 70% of the state's total urban waste output. In response to waste management challenges, GMC has privatized door-to-door waste collection and transportation services. However, this move has sparked discussions regarding the effectiveness and equity of privatization in waste management. ​ The Martam landfill, inaugurated in 2017 with an expected lifespan of 17 years, has become overburdened ahead of schedule due to waste from across Sikkim being dumped there. This has led to environmental and logistical challenges, prompting the initiation of a biomining project in January 2024 to manage waste scientifically and mitigate environmental impacts.

Sikkim has been proactive in implementing environmentally friendly policies. Despite the efforts, challenges persist, especially with the increasing number of tourists and the resultant waste generation. The state government has also focused on scientific waste management practices, such as the biomining project at Martam landfill, which aims to reduce waste volume, recover resources, and improve land use using biological methods. This initiative is part of a broader strategy to achieve a zero-waste situation in the state.

Conclusion

**Sikkim's waste management trends from 2016–17 to 2023–24 reflect significant progress in efficiency and a shift towards sustainable practices. However, challenges remain, particularly concerning landfill overcapacity and the integration of informal waste workers into formal systems. Continued efforts in policy implementation, infrastructure development, and community engagement are essential to address these challenges and move towards a more sustainable waste management system.**

References:

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