ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor (RJIF): 8.4
IJAR 2025; 11(5): 286-291
www.allresearchjournal.com
Received: 23-03-2025
Accepted: 28-04-2025

Rohit Prakash
Research Scholar, P.G., Department of Geography, V.K.S. University, Ara, Bihar, India

Dr. Sadaf
Assistant Professor, PG, Department of Geography, Veer Kunwar Singh University, Ara, Bihar, India

Corresponding Author:
Rohit Prakash
Research Scholar, P.G., Department of Geography, V.K.S. University, Ara, Bihar, India

Spatial pattern of solid waste generation in Ara city, Bihar

Rohit Prakash and Sadaf

DOI: https://www.doi.org/10.22271/allresearch.2025.v11.i5d.12573

Abstract
Large-scale solid waste generation is still one of the key environmental issues facing developed as well as developing nations today. In the majority of the developing world, the production of solid waste has not been determined. Global solid waste generation is rising as a result of urbanization, population growth, substantial growth of the economy and rising living standards. According to the Ara Municipal Corporation, the average person produces 0.450 kg of solid waste per day, with dry, liquid, and hotel and food wastes making up 60, 40, and 10 percent of the total. The present paper attempts to analyze the spatial distribution of Ara city's solid waste generation in relation to its population. All of the necessary data and information have been obtained from secondary sources. These consist of secondary sources, interviews, and municipal data collecting. The Arc GIS 10.8 software was utilized to create the map. The results indicate that the generation of solid waste in Ara city varies geographically. Wards with a high population density produce more waste, and vice versa. With the increasing number of urban dwellers, waste management systems are unable to meet the demands of solid waste collection, treatment, and disposal. The absence of a scientific landfill site in the city at the present time is impeding the city's well-being. Through their ramifications, solid waste management needs to be improved at both the centralized and decentralized levels. To achieve solid waste management's long-term goal for the city's successful development. Ara municipality needs work with certain notable formal and informal sectors and organizations.

Keywords: Solid waste generation, waste management, solid waste disposal, landfill site

Introduction
The global increase in solid waste generation is largely due to changing lifestyles and consumption patterns. High-income countries generate more waste due to their diverse lifestyles and purchasing power. Proper waste management is crucial for environmental cleanliness and sustainability. The quantity and composition of generated waste are essential for proper disposal. Recyclable materials like paper, cardboard, and plastic require daily collection and disposal, as they hold immediate monetary value [1]. According to Bamgbose *et al*. (2000), solid wastes are leftovers or abandoned items and materials from daily activities, mining, industry, commerce, and agriculture [2]. Since the dawn of civilization, solid waste has been produced. Solid waste disposal was simple and unimportant at the time because there was a lot of open space and a low population density [3]. However, as time went on, the world's solid waste generation increased due to rapid economic growth, urbanization, rising human population, and rising living standards. One of the biggest environmental issues facing developed as well as developing nations today is the massive volume of solid garbage that is produced.

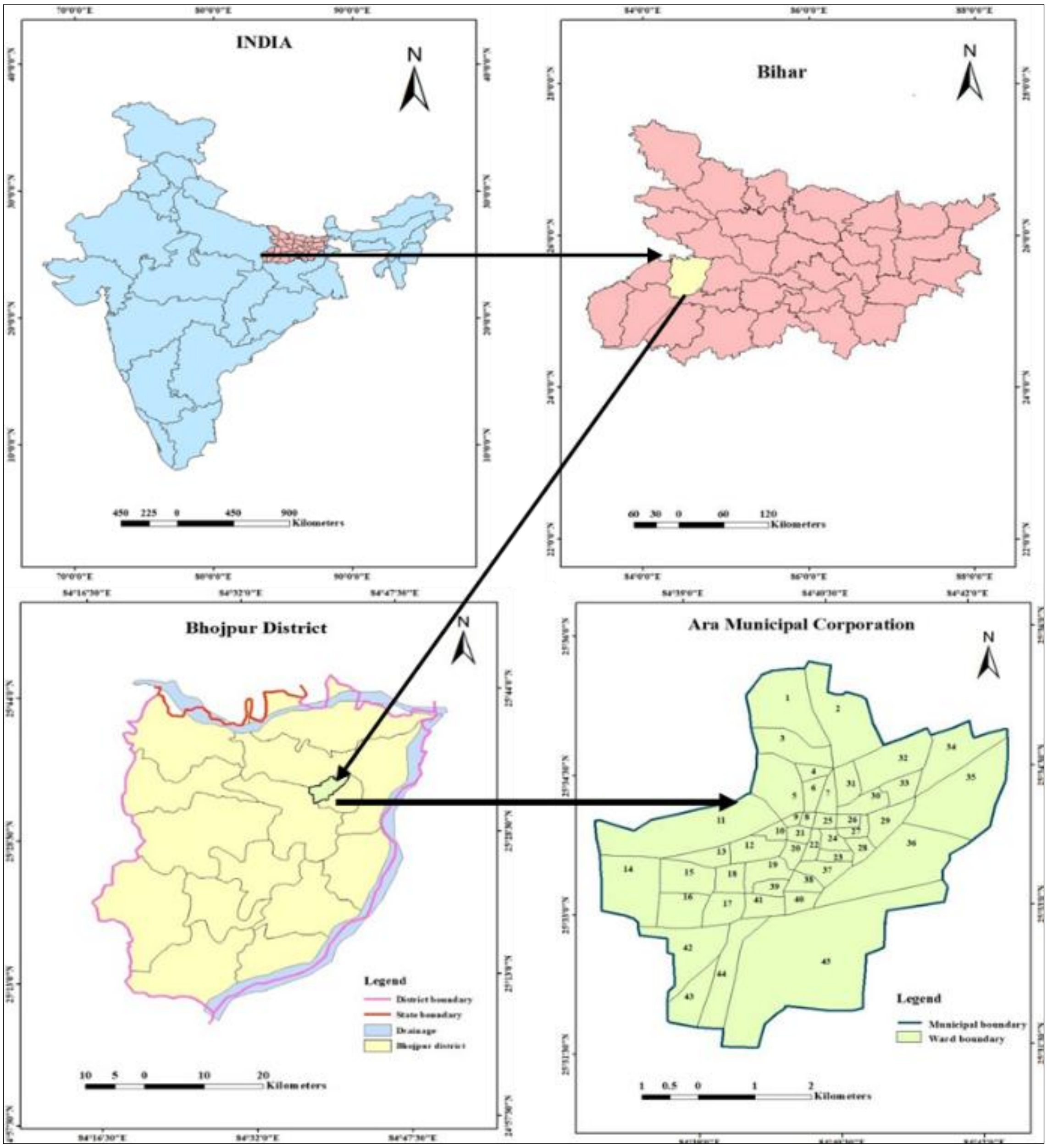
In countries with low and middle incomes, its management is viewed as one of the neglected aspects. India's agriculture-based economy is quickly giving way to one that is focused on industry and services. Its four seasons (summer, rainy, winter, and autumn) and various geographic and climatic regions (tropical wet, tropical dry, subtropical humid, and mountain climate) result in varying consumption patterns among the local population, which in turn causes variations in the pattern of solid waste generation. The consumption of goods and the production of garbage are both significantly impacted by globalization (J. Rajkumar & A. Sirajuddin, 2016) [4]. It is widely recognized that Bihar is regarded as one of India's less developed states. The same is true for solid waste management. Due to a lack of adequate expertise and equipment, waste management and disposal remain one of Bihar's most overlooked topics and major issues. Municipal solid waste generation is expected to rise from the current level of 680 tons per day (TPD) to 1537 TPD by 2030, necessitating improvements to the state's solid waste management system [5].

We discussed about the state of Bihar's Ara city, which is the biggest city in the Bhojpur district.

The average daily solid waste production in Ara City is currently 0.450 kg per person, with dry, liquid, and hotel and food wastes making up 60, 40, and 10 percent of the total 110 tons of solid garbage generated daily from all 45 wards located here. Ara Municipal Corporation is managing the aforementioned volume of solid garbage collectively with the assistance of 1212 municipal employees [6]. Because of inadequate planning, inadequate infrastructure, unscientific treatment, improper collection, low technology utilization, and rapid population expansion, solid waste management (SWM) is a critical issue in the city that inevitably impacts the environment, socioeconomic situations, and health. The Ara population grew by 28.37 percent each decade between 2001 and 2011 [7]. Due to the district's concentration of commercial, educational, and hospital facilities, Ara generates more solid waste, making its management a critical concern. Due to inadequate domestic garbage disposal, solid waste has accumulated at street corners and open spaces as a result of the city's current congestion. Poor solid waste management in the city is caused by a lack of services and infrastructure, a lack of funding, a lack of organization, and inadequate technology. The issues with solid waste are not limited to the municipal limits; they also have a significant impact on the surrounding areas.

Study Area

Ara city lies between 25°33′24″N and 84°40′9″ E in the Bhojpur district of Bihar (fig.1). It is the headquarter of Bhojpur, located near the confluence of the Ganges and Sone rivers.



Source: Prepared by researcher based on Census of India, 2011

Fig 1: Study area

Table 1: Ward wise total populations, area and density of population of Ara Municipal Corporation (2011& 2024)

Ward No.	Area of the ward (sq. km)	Pop. (2011)	Pop. (2024) *	Pop. Density (2011)	Pop. Density (2024)
01	1.345367	3950	5590	2936	4154
02	1.506154	4550	6439	2623	4274
03	0.691657	5538	7837	8007	11330
04	0.15395	3373	4773	21910	31003
05	0.836241	6020	8519	7199	10186
06	0.213949	4133	5849	19318	27336
07	0.19528	4368	6181	22368	31652
08	0.072952	4560	6453	62507	88452
09	0.069799	4683	6627	67093	94941
10	0.143628	4405	6233	30669	43399
11	2.284345	7477	10581	3273	4631
12	0.387661	4400	6226	11350	16061
13	1.2359	4646	6574	3759	5319
14	0.282829	10420	14745	36842	52134
15	0.581546	8438	11940	14509	20532
16	0.573725	2951	4176	5143	7278
17	0.423896	6113	8650	14421	20406
18	0.285745	3015	4266	10551	14931
19	0.382153	4533	6415	11862	16785
20	0.182108	5134	7265	28192	39894
21	0.122992	3559	5036	28937	40947
22	0.14427	5476	7749	37956	53711
23	0.131503	4170	5901	31710	44872
24	0.17992	7277	10298	40446	57233
25	0.113621	6825	9658	60068	85001
26	0.099214	6987	9887	70424	99654
27	0.147159	7439	10527	50551	71533
28	0.163138	3320	4698	20351	28798
29	0.355589	4528	6407	12734	18019
30	0.296033	4610	6524	15573	22036
31	0.314823	5878	8318	18671	26420
32	0.976435	5988	8473	6133	8677
33	0.282112	8663	12259	30708	43453
34	1.018658	7232	10234	7010	10046
35	1.958008	6249	8843	3192	4516
36	2.182395	6634	9388	3040	4301
37	0.284485	7544	10675	26518	37525
38	0.205595	8534	12076	41509	58738
39	0.165262	5371	7600	32500	45989
40	0.250284	4544	6430	18155	25691
41	0.248605	4024	5694	16186	22904
42	1.066056	11333	16037	10631	15043
43	0.552254	8377	11854	15169	21464
44	0.858566	6819	9649	7942	11239
45	5.815672	7342	10390	1262	1786
Total		261430	369944		

Source: Computed by researcher based on Ara Municipal Corporation (2024) and Census of India (2011)
Note: * indicate the projected population of Ara Municipal Corporation (2024)

As per the 2011 Census, Ara Municipal Corporation had a total population of 2,61430 out of which 1,38804 were male and 1,22626 were females. Ara city has 39274 households and it is divided into 45 wards (table 1) [8].

Database and Methodology

The present study is based on secondary sources of data collected from different published and unpublished records from concerned departments and institutions such as the Ara Municipal Corporation and the state pollution control board. Ward-wise data related to the total population and density of population have been collected from the district census handbook and village and town directory, 2011. Ward-wise data related to solid waste generation has been collected from Ara Municipal Corporation for the year 2011 and 2024.

Methodology

Calculation of Population Density: Population density has been measured in this paper using the following equation: -

$$\text{Density of Population (Ward wise)} = \frac{\text{Total Population}}{\text{Area of ward}}$$

Estimation of Solid Waste generation: Solid waste generation has been calculated (in gm) in this way that total population of a particular ward multiplied by 0.450 gm solid waste generated per day/person for 2024 and total population of a particular ward multiplied by 0.40 gm solid waste generated per day/person for 2011.

Solid Waste generated/day (for a Ward) = Population of a particular ward x 0.450 gm for 2024 Solid Waste generated/day (for a Ward) = Population of a particular ward x 0.40 gm for 2011.

Estimation of Density of Solid Waste Generation: Density of solid waste generation has been calculated with the help of following formula:

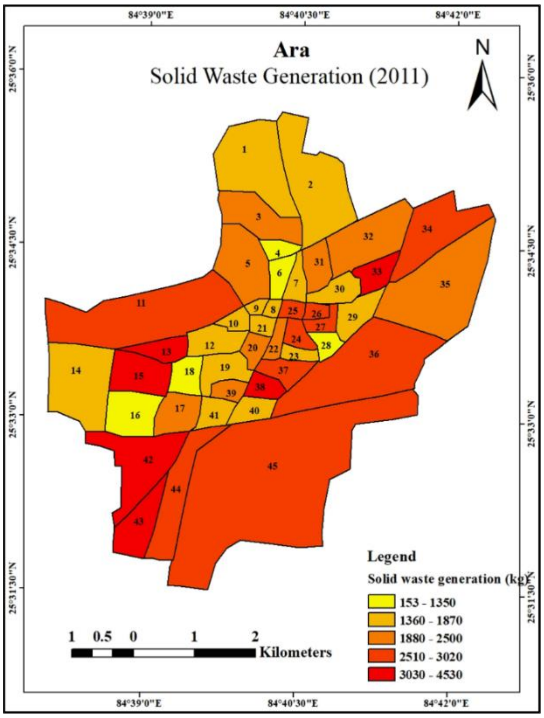
$$\text{Density of Solid Waste Generation (ward wise)} = \frac{\text{Total solid waste generated}}{\text{Area of ward}}$$

Projected Population: Based on population data of census year 2001 and 2011, the projected population of 2024 has been calculated with the help of following formula: -

$P_i = P_o\,(1 + r)^n$

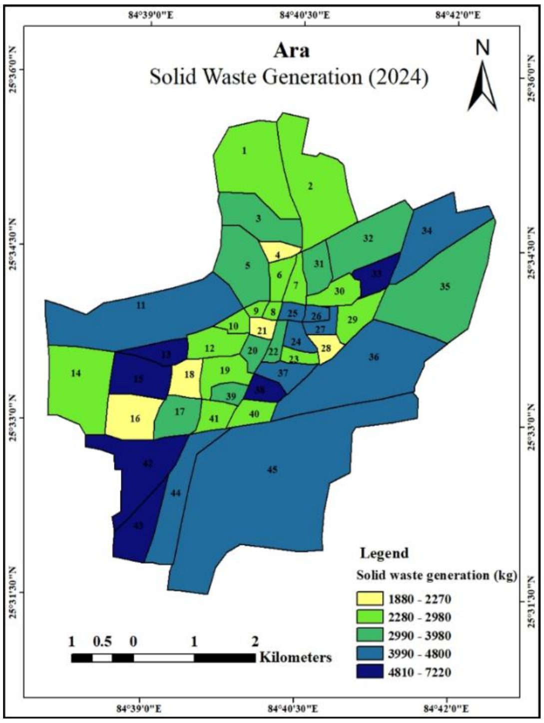
Where,
P_i=Population in target year
P_o=Population in base year
n=number of years.
r=Growth rate.
For Ara city, the Growth rate used is 2.51%. Where, the population in Census year 2001 was 203380 and in 2011 it was 261430.

Results and Discussion
Solid Waste Generation
The generation of solid waste is influenced by a number of factors, including socioeconomic status, urbanization, public habits, attitudes, and changing lifestyles, as well as regional climate and seasonal conditions. There is a favorable relationship between solid waste generation and socioeconomic status [9]. Ara City, which has a population of 261430 and 45 wards, generates 104572 grams of solid waste every day in 2011. Based on the estimated population for 2024, Ara City, which has a population of 369944 and 45 wards, generates 166475 grams of solid waste every day in 2024. According to the data, there are considerable spatial variations in the quantity of solid waste produced in different wards. Table 02 illustrates the city's solid waste generation patterns by ward. In 2011, ward number 42 generated the most solid waste, 4533.2 grams per day per person. With a population of 11333, this ward encompasses the new settlements with the highest volume of waste production, whereas ward no. 16 (fig. 2) has the lowest volume of solid waste creation, with a generation rate of 1180.4 grams per day per person and a population of 2951. Wards 13, 15, 33, 38, 42, and 43 also have the greatest rates of solid trash generation. The following wards have moderate solid waste generation: 1, 2, 3, 5, 7, 8, 9, 10, 11, 12, 14, 17, 19, 20, 21, 22, 23, 24, 25, 26, 29, 30, 31, 32, 34, 35, 36, 37, 39, 40, 41, 44, and 45. Additionally, 4, 6, 16, 18, and 28 have the lowest rates of solid waste generation. In 2011. Based on the estimated population for 2024 ward number 42 (fig. 3), which has 16037 people living there, generates a significant quantity of solid waste (7217 gm/day/person), while ward number 16, which has 4176 residents, generates the least amount of solid waste (1879 gm/day/person). Result shows that there is a direct correlation between the amount of solid garbage generated and the city's population. Specifically, wards 13, 15, 33, 38, 42, and 43 have the greatest rates of solid waste generation. The following wards have moderate solid waste generation: 1, 2, 3, 5, 7, 8, 9, 10, 11, 12, 14, 17, 19, 20, 21, 22, 23, 24, 25, 26, 29, 30, 31, 32, 34, 35, 36, 37, 39, 40, 41, 44, and 45. Additionally, 4, 6, 16, 18, and 28 have the lowest rates of solid waste generation in 2024. Result shows that a ward with a higher population produces more solid waste, and vice versa.



Source: Prepared by researcher based on Ara Municipal Corporation, 2011

Fig 2: Solid waste generation in Ara Municipal Corporation (2011)



Source: Prepared by researcher based on Ara Municipal Corporation, 2024

Fig 3: Solid waste generation in Ara Municipal Corporation (2024)

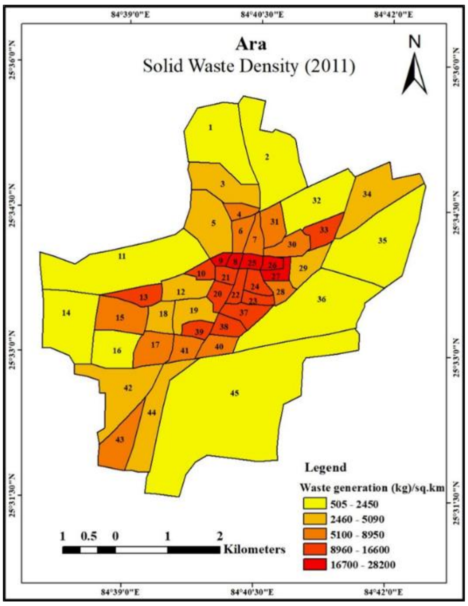
Table 2: Ward wise solid waste generation in Ara Municipal Corporation (2011 & 2024)

Ward No.	Solid Waste generation in 2011 (in gm)	Solid Waste generation in 2024 (in gm)
01	1580	2515
02	1820	2897
03	2215.2	3527
04	1349.2	2148
05	2408	3833
06	1653.2	2632
07	1747.2	2781
08	1824	2904
09	1873.2	2982
10	1762	2805
11	2990.8	4761
12	1760	2802
13	1858.4	2959
14	4168	6635
15	3375.2	5373
16	1180.4	1879
17	2445.2	3893
18	1206	1920
19	1813.2	2887
20	2053.6	3269
21	1423.6	2266
22	2190.4	3487
23	1668	2655
24	2910.8	4634
25	2730	4346
26	2794.8	4449
27	2975.6	4737
28	1328	2114
29	1811.2	2883
30	1844	2936
31	2351.2	3743
32	2395.2	3813
33	3465.2	5516
34	2892.8	4605
35	2499.6	3979
36	2653.6	4224
37	3017.6	4804
38	3413.6	5434
39	2148.4	3420
40	1817.6	2894
41	1609.6	2562
42	4533.2	7217
43	3350.8	5334
44	2727.6	4342
45	2936.8	4675
Total	104572	166475

Source: Computed by researchers based on Ara Municipal Corporation (2011 & 2024)

Density of solid waste generation

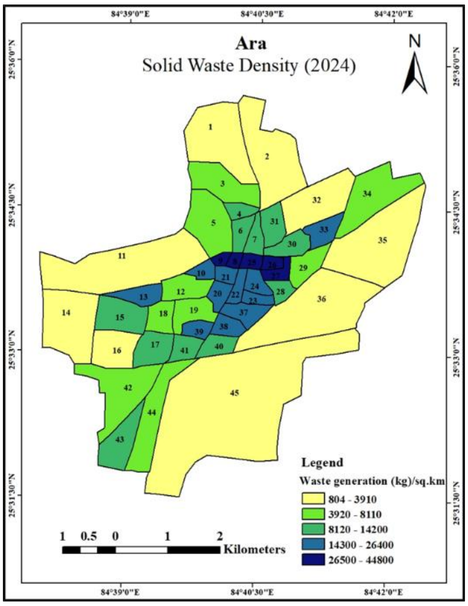
The solid waste generation density for each of the 45 Ara city wards in 2011 and 2024 is shown in Table 3. Ward No. 26 has the highest density of solid waste creation in the study region, with 28169 people per square kilometer in 2011 and 44845 people per square kilometer in 2024; ward No. 45 has the lowest density, with 505 people per square kilometer in 2011 and 804 people per square kilometer in 2024 (figs. 4 and 5), respectively. In 2011, ward number 26 had the highest density of solid waste generation (28169 gm/sq.km), while ward number 45 had the lowest density (505 gm/sq.km). Wards 8, 9, 25, 26, and 27 had the highest rates of solid waste density in 2011.



Source: Prepared by researcher based on Ara Municipal Corporation, 2011

Fig 4: Density of Solid waste generation in Ara Municipal Corporation (2011)

The following wards have a moderate solid waste density: 3,5,7,10,12,13,15,17,18,19,20,21,22,23,24,28,29,30,31,33,34,35,36,37,38,39,40,41,42,43, and 44. Additionally, ward numbers 1, 2, 11, 14, 16, 32, 35, 36, and 45 have the lowest densities of solid garbage. However, based on the estimated population for 2024, ward number 26 has the highest density of solid waste creation (44845 gm/sq.km.), while ward number 45 has the lowest rate (804 gm/sq.km.). Wards 8, 9, 25, 26, and 27 have the highest rates of solid waste density. Wards 1, 2, 3, 5, 7, 8, 9, 10, 11, 12, 14, 17, 19, 20, 21, 22, 23, 24, 25, 26, 29, 30, 31, 32, 34, 35, 36, 37, 39, 40, 41, 44, and 45 have a moderate density of solid waste. Wards 4, 6, 16, 18, and 28 have the lowest rates of solid waste density. Result indicates that a ward with a higher population density produces more solid waste, and vice versa.



Source: Prepared by researcher based on Ara Municipal Corporation, 2024

Fig 5: Density of Solid waste generation in Ara Municipal Corporation (2024)

Table 3: Ward wise Density of solid waste generation in Ara Municipal Corporation (2011 & 2024)

Ward No.	Density of Solid Waste Generation (2011)	Density of Solid Waste Generation (2024)
01	1174	1870
02	1208	1924
03	3203	5099
04	8764	13952
05	2880	4584
06	7727	12301
07	8947	14244
08	25003	39803
09	26837	42724
10	12268	19530
11	1309	2084
12	4540	7228
13	1504	2394
14	14737	23460
15	5804	9240
16	2057	3275
17	5768	9183
18	4221	6719
19	4745	7553
20	11277	17952
21	11575	18427
22	15183	24170
23	12684	20193
24	16178	25755
25	24027	38251
26	28169	44845
27	20220	32190
28	8140	12959
29	5094	8109
30	6229	9916
31	7468	11889
32	2453	3905
33	12283	19554
34	2840	4521
35	1277	2032
36	1216	1936
37	10607	16886
38	16604	26432
39	13000	20695
40	7262	11561
41	6475	10307
42	4252	6770
43	6067	9659
44	3177	5058
45	505	804

Source: Computed by researchers based on Census of India and Ara Municipal Corporation (2011 & 2024)

Conclusion

Commercial, residential, institutional, street sweeping, drain silting, and construction all contribute to a generation of solid waste. In the research area, there is a positive correlation between the population and the amount of solid waste generated. Urbanization, altering socioeconomic conditions, public habits, attitudes, and lifestyles, as well as regional climate and seasonal conditions, are all contributing factors to the dramatic rise in solid waste. For instance, when someone tries to maintain a higher standard of living, he upgrades himself by using different kinds of commodities, which ultimately contributes to the rise in the rate of solid waste by leaving behind unused waste materials or byproducts. On average, each person in Ara City produces 0.450 kg of solid waste per day. This is divided into 60, 40, and 10 dry, liquid, and hotel and food wastes, for a daily total of 110 tons of solid waste generated from a variety of sources, of which 50% are residential, 15% are commercial, 5% are institutional, and 30% are from street sweeping, drain silting, and construction. The amount of solid waste processed daily (TPD) is 02 tons per day, while the remaining 108 tons of solid waste are disposed of, per the data gathered from AMC. Solid waste is processed via the composting method. There are thirty pits ready to process two tons of it. One ton in the pits and one ton in the toner machine. Solid trash recycling in the city is a very small percentage. Additionally, the local body does not have any waste sites. A comprehensive approach is required to address the problem of sustainable management of MSW because there isn't a single solution.

Acknowledgement

The authors express their gratitude to the Vice Chancellor, Veer Kunwar Singh University, Ara, Bihar, and the Head of the P.G. Department of Geography, Veer Kunwar Singh University, Ara, Bihar, for providing all necessary resources. The authors also acknowledge the Ara Municipal Corporation, Ara, Bhojpur for providing essential data and information.

References

1. SK MM. Spatial analysis of solid waste generation patterns in a fast-growing industrial city—Durgapur, India. JETIR. 2023;10(7):245-253.
2. Bamgbose O, *et al*. Assessment of urban solid waste management practices in Lagos, Nigeria. Afr Sci. 2000;1(1):23-31.
3. Sharma CK. Solid, Liquid & Hazardous Waste Management. Guwahati: Foundation Publishing House; 2022.
4. Joshi R, Ahmed S. Status and challenges of municipal solid waste management in India: a review. Cogent Environ Sci. 2016;2:1139434. doi:10.1080/23311843.2016.1139434.
5. Bihar State Pollution Control Board. Annual Report. Patna: Bihar State Pollution Control Board; 2023.
6. Arrah Municipal Corporation. Annual Report. Arrah, Bhojpur: Arrah Municipal Corporation; 2023.
7. Office of the Registrar General & Census Commissioner, India. Primary Census Abstract and Provisional Population Totals. New Delhi: Census of India; 2011.
8. Hazra T, Singh AK. Status of solid waste management: a global perspective. Uttar Bharat Bhoogol Patrika. 2017;47(1):11-22.