Research Article

Evaluation of Solid Waste Management in Koya City

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Abstract

The management of solid waste (SW) is a growing challenge for urban areas, including the Koya District, where domestic waste generation has escalated due to population growth and changing consumption patterns. This study aims to assess the current reality of household solid waste management in Koya District, focusing on the initial stages of the process: quantifying and estimating the amount of domestic waste generated and analyzing its composition. In order to achieve this goal, a field survey was conducted to determine the composition and rate of domestic solid waste production for a group of families that were selected from the neighborhoods in koya city , and who compared the results with the data of the koya municipality that manages solid waste in the Koya District and the results showed that the rate of solid waste production Household waste (1.035 kg / person/day) for Koya city and the lowest percentage in ashti (0.73 kg / person/day)district and the highest percentage in Shoresh district(1.21 kg / person/day). The household waste generation only about 121 tons per day of paper, food, glass, metallic, plastic, others clothes and dust, addition to organic materials that are possible Using them for soil improvement by composting, but all components of SW are buried in a landfill without 4R Reduce, Reuse, Recycle and Replace.

1. Introduction

The term SW solid waste can be used for urban waste, which includes seven categories: household waste, commercial waste, institutional waste, street waste, building and degradation, sanitation and industrial waste [1]. Solid urban waste often refers to solid waste, often in municipality or other government bodies, from the

homes, streets and public areas, stores, offices and hospitals. Solid waste is usually not renewable as municipal from industrial processes. As this waste ends in a municipal waste stream, however, it should be included in solid waste management. Solid waste is as useless and sometimes dangerous material with a low liquid content, and it includes municipal waste, industrial waste, commercial waste and waste resulting from agricultural operations, animal husbandry and activities. (Other associated and demolition waste) Solid waste represents one of the growing problems facing the municipality Koya and its related aspects. What makes this problem exacerbate dramatically is the increase in population, rapid urban development, and the failure to follow appropriate methods of solid waste management. Also, the low level of environmental awareness in solid waste management has made the problem with negative consequences.

Internationally, creative waste management systems, waste disposal solutions such as incineration and conflicts over the selection of waste disposal sites (landfills and incineration) in world.

In First Nations communities have been the focus Cost control and goods for the environment are the key questions, increased population and urban development and industrialization faced by African, Asian and South American developing countries all point to more rises in waste [2].

Urbanization and commercial/industrial growth led to the increasing of waste which must be properly accumulated. The management of solid waste is one of the key duties of the urban as well as rural communities and the fundamental goal of the programs for the management of solid waste is to reduce environmental contamination. In developing countries per-capita waste generation rates are lower than in higher-income countries, but capacity of developing countries for waste management, recycling, reuse and disposal is limited by the local authorities responsible [3].

Solid waste is one types of useless solid materials or waste which are unwantedly generated from human activities domestic commercial areas, residential, industrial. The contents of SW are paper, glass, organic material, metal, plastic etc. Change in the physical and chemical composition SW with time, also there is a potentiality of hazardous components such as toxic, non-toxic, flammable, radioactive, infectious etc.

According to Planning Commission the total The total SW quantity created in urban India is estimated in the Planning Commission report5 to be 62 million tons annually (TPY) (0.573 million tons per day, MMT per day), with an estimated 165 million tonnes per year in the urban center by 2031, and 436 million tonnes by 2050 [4], [5], [6].

Table (1) change in sources of municipal solid waste [6].

Year	Bio-degradable	Paper	Plastics	Metal	Glass	Rags	Inert	others
1996	42.21	3.63	0.6	0.49	0.6	0	45.13	0
2005	47.43	8.13	9.22	0.5	1.01	4.49	25.16	4.02
2011	42.51	9.63	10.11	0.63	0.96	0	17	0

Solid Waste Management (SWM) [7] is one form of management system which reduces or eliminates the adverse impact on the environment & human health generated by different types waste. Each municipality tries to give to its habitants the SWM facility. In United states of Americas, few decades earlier itself watertight garbage cans were first introduced and sturdier vehicles were used to collect and transport wastes. Slowly the changes occurred through the global context and in today's scenario a number of different processes are involved in effectively managing waste from the municipal areas. Among all these mentioned steps of waste management, solid waste collection (SWC) [7], process, deals with different challenging issues . In this process normally vehicles starts with different human resources from their sources (say from office complexes or from collection centers).

During the collection period from various areas or regions, vehicles generally keep their engines operating even when waste bins are loaded, resulting in an enormous consumption of fuel and higher emissions Every month a large amount of the total

budget allotted for SWM by state or central government are used for SWC process and these budgets goes to fuel consumption only [8]. waste collections are conducted without perceiving or analyzing demand and the drivers are normally responsible to construct travelling routes for waste collection. Therefore, various researches [4], [9], [10] have showed that diverse advance technologies including information , time, risk and environment. In this work mainly the focus is given on the overall Municipal solid waste management system with the help of recent advance technologies, as this wastes is coming under the umbrella of SW, so formally the overall management techniques for handling these wastes are considered. What makes it hard for people to handle is that most people living in settlements that are spontaneous and often illegal outside government controls, most of whom are poor and are not subject to law .

It should be remembered that deteriorating health conditions are not only affecting the inhabitants of low-income communities, but the general population. According to [2] most of the waste generated around the world (57 to 85%) has been disposed primarily in sites, including open and manufactured sites.

Methods for the disposal of solid waste differ dramatically with waste forms and local circumstances. Thus, waste management systems should take into account the fundamental objectives, a thorough consideration of local circumstances and causes, an appreciation of the full spectrum of available technology solutions and a knowledge of the traditional know-how and systems built by local residents [11]. Municipal waste disposal is one of the most severe and contentious urban problems in most developing countries. Local governments are facing it. In spite of emerging technologies, production decisions and consumer strata, per capita waste generation continues to increase

The level of income of population and city volume effect on see table (2)

table (2) solid waste quantities generation according to income and city volume kg/Capita/day [12]

	Low-income country	Middle income country	High income country
Mixed urban waste large city	0.5-.75	0.55-1.1	0.75-2.2
Mixed urban waste small to medium city	0.35-0.65	0.45-0.75	0.65-1.5
Residential waste only	0.25-0.45	0.35-0.65	0.55-1.0

also, the SW quantity depends on general consumer habits and a country's level of technical development It is a popular sense that waste in the wrong location is nothing other than useful material and, in the world, there is no material that is not useful [12]. Waste management has become an urgent problem for industrial societies as a result of economic development and lifestyle decisions they generate vast amounts of waste. The solutions to the issue are not complete with waste management technologies like landfill site selection and incineration [13]. People shift their attitude towards waste as waste forms. It has led people to understand that the alternative is to use waste instead of destruction as a resource. Public sensitivity and waste attitudes will impact the population Willingness to engage in proper waste management activities.

This study aims to evaluate household solid waste management in Koya District, focusing on the initial phases: quantifying and estimating the volume of domestic waste generated and analysing its composition.

This contributes to safeguarding human health, protecting the environment, and conserving natural resources.

This study represents one of the proposed projects to protect the environment of Kurdistan, the first stage of solid waste management generated in the city is to know the rate of per capita production of household solid waste in Koya district (the study area) and also to calculate the rates of all waste components and find their proportions. Security for solid waste, whether by reducing the volume of solid waste from the source, by educating the citizen about the importance of reducing it and using tools that can be reused again, such as plastic or paper materials, or recycling what can be recycled from materials such as paper or materials Plastic or organic plant and animal solid waste and construction waste.

2. Study area

Koya district has an important geographical location, as it is located between three governorates, Sulaymaniyah, Kirkuk and Erbil, and it is bordered on the east and south by the Lower Zab River that separates it from the Kirkuk and Sulaymaniyah governorates and from the north-east by Mount Heibat Sultan And embraced from the west by Mount Bawaji. Koya district was divided into six municipalities koaya , taq taq, segrdakan , shorash , shorash , ashti ,and saktan. The location of municipalities shown in Fig. 1.

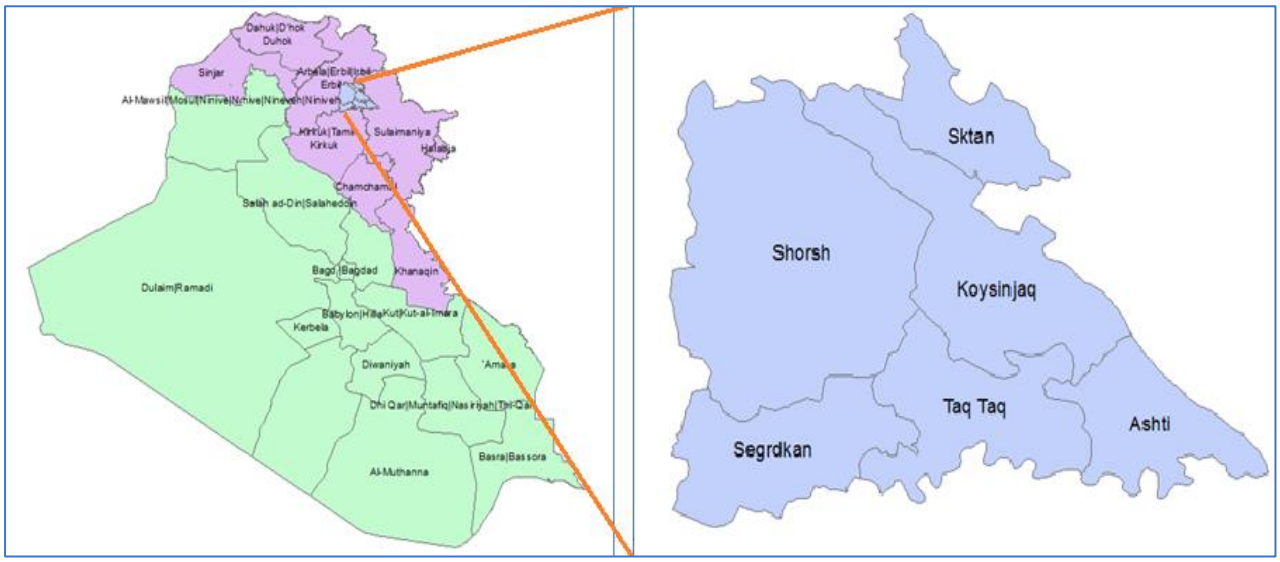

Fig. (1) location of study area Koya district

3. Materials and Methods

3.1 Population Estimation

The population of Koya is a key element in the assessment of the quantities of solid waste generated. One method for estimating the total amount of solid waste generated is to rely on published data for countries with similar socioeconomic indicators and obtain the amount of waste per capita per day. This number multiplied by the population being studied can provide the total amount of the generated waste. As can be expected, data on the population of Koya district.

According to the municipality of koya a census conducted on indicated that the total population of district 119640 capita , see fig (2) [14]

This data was adopted in this research for solid waste generation rate study. In order to help in our evaluation of the waste management

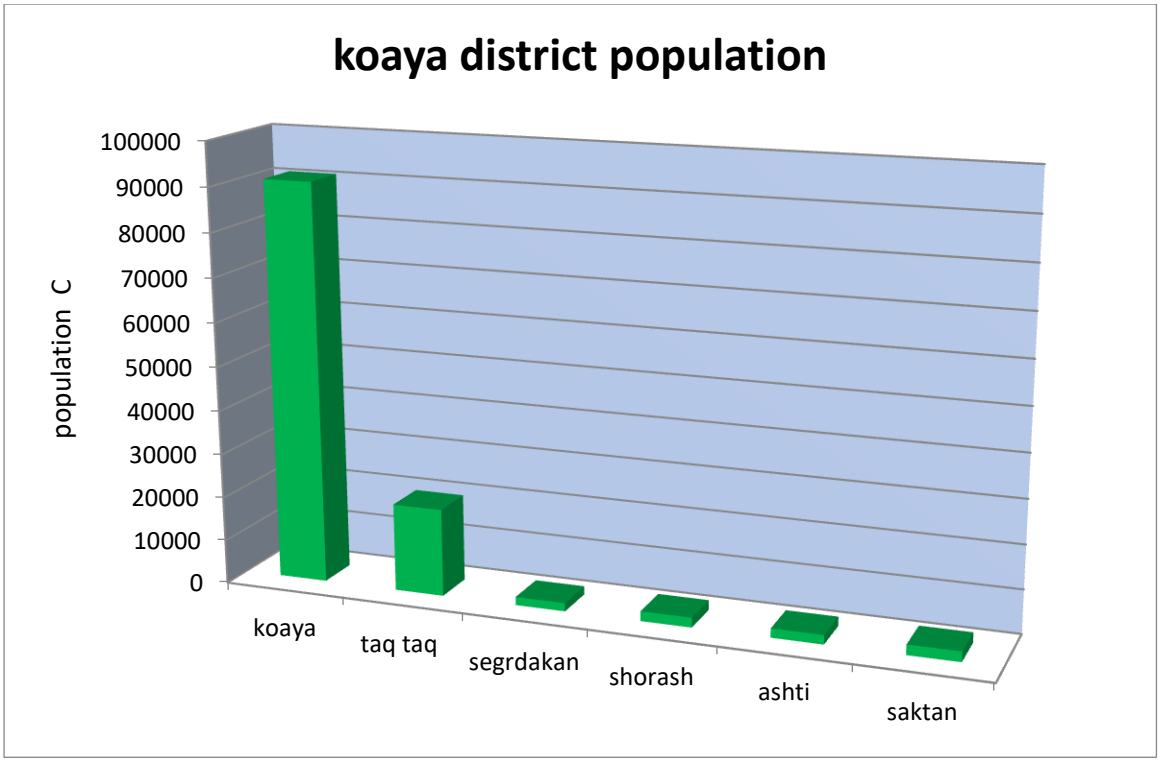

fig (2) population of koya district [12]

3.2 Waste Generation Rate Adopted Population of koya by District

According to [14] summary Solid waste generation and collection service in koya district from 1/1 to 1/7 / 2019 are in the table (3) and fig (3) daily solid waste generation of koya district Kg per capita .

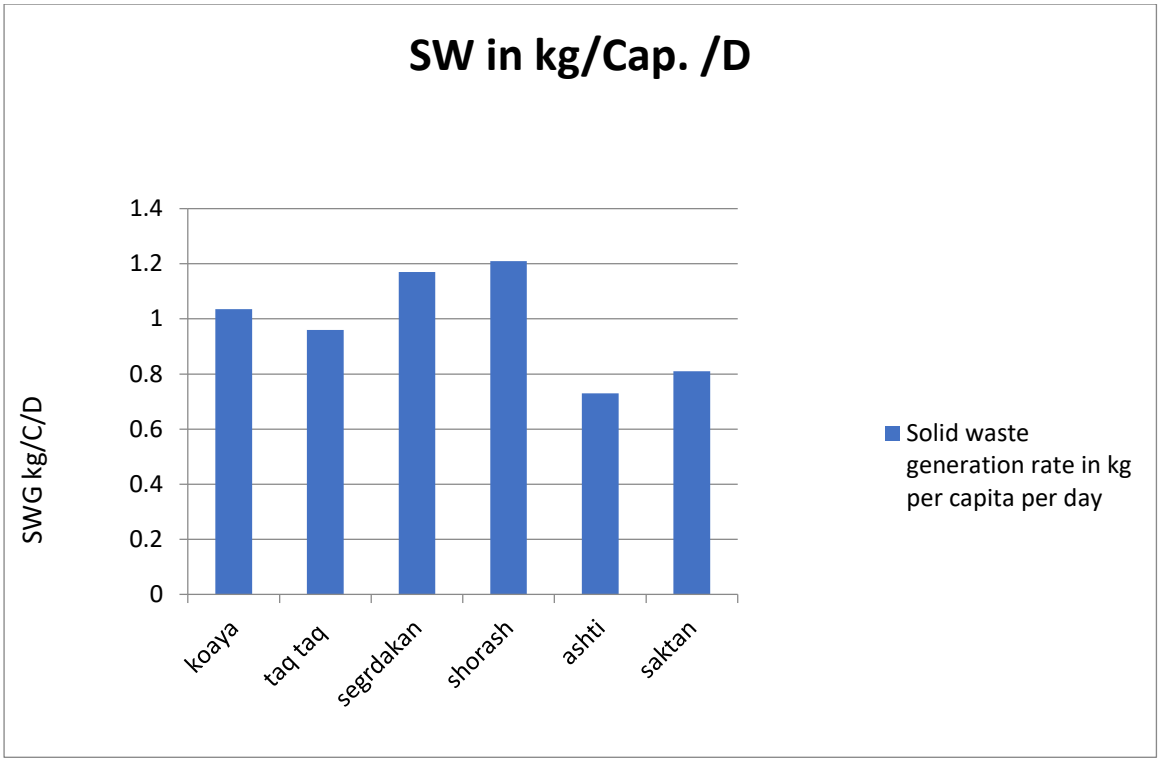

fig (3) daily solid waste generation of koya district Kg per capita [14]

the table (3) summary Solid waste generation and collection service in koya district from 1/1 to 1/7 / 2019 [14]

no.	mincipality	company	population	daily SWG kg/C/d	daily waste generation kg	annually SWG ton /y
1	koaya	papa group	91000	1.035	94148	34364
2	taq taq	papa group	20000	0.96	19143	6987.2
3	segrdakan	papa group	1900	1.17	2223	811.395
4	shorash	papa group	2250	1.21	2723	993.895
5	ashti	papa group	2130	0.73	1549	565.385
6	saktan	papa group	2360	0.81	1914	698.61
	Total		119640	Mean =0.986	121700	44420.5

So, the data on solid waste generation rate indicate that the average solid waste generation are 0.986kg/kapita /day and the total are about 44420.5 tones/year, throws garbage into land fill without any treatment as shown in Fig.4.

Fig (4) Land fill site in Koya

4. Results and discussion

In order to measure the real SW generated by households, selected three specific neighbourhoods—Heibat Sultan, Azadi, and Iskan. These areas were selected based on their population density, diversity of household types, and socio-economic factors. Understanding the waste generation patterns in these areas can provide insight into the overall waste production of Koya City.

To accurately assess the solid waste generated by households, families consisting of five members were chosen from each neighbourhood. The data collection spanned seven non-consecutive days. This approach ensures variability in waste generation and accounts for daily and seasonal fluctuations in waste production. The methodology involves:

1. **Selection of Households**: Families with five members were chosen to standardize the data and to make comparisons between neighbourhoods easier.
2. **Duration**: Waste generation was monitored for seven non-consecutive days to get a comprehensive view of daily waste patterns while avoiding bias that may come from specific days (such as weekends or holidays).
3. **Data Collection**: Each household was provided with bags to segregate their solid waste, which was collected and weighed daily. Types of waste such as

organic, recyclable, and non-recyclable materials were recorded to better understand the composition of waste in the city.

The tables 4, 5, and 6. Showed the SW generation data for the selected areas.

Table (4) Solid waste component measured by researcher in haibat sultan koya

No.	Date	Solid waste component (kg/d)						Total weight	Weight /capita
		food	paper	metallic	plastic	Glass	cloth and dust		
1	24/12/23	2.72	0.32	0.26	0.56	0.00	0.46	4.32	0.86
2	26/12/23	3.54	0.26	0.29	0.45	0.00	0.35	4.88	0.98
3	28/12/23	3.04	0.34	0.30	0.35	0.62	0.56	5.22	1.04
4	1/1/24	3.52	0.30	0.35	0.46	0.00	0.18	4.82	0.96
5	3/1/24	3.36	0.29	0.27	0.43	0.91	0.88	6.14	1.23
6	6/1/24	3.04	0.38	0.34	0.54	0.53	0.80	5.63	1.13
7	10/10/24	1.76	0.42	0.43	0.53	0.00	1.28	4.42	0.88
Summation								35.42	7.08

The average solid waste generation for haibbat sultan are 7.08/7 = 1.01 kg/capita/d,

Table (5) Solid waste component measured by researcher in azadi koya

No.	Date	Solid waste component (kg/d)						Total weight	Weight /capita
		food	paper	metallic	plastic	Glass	cloth and dust		
1	24/12/23	2.88	0.18	0.24	0.24	0.80	0.32	4.66	0.93
2	26/12/23	3.04	0.24	0.30	0.35	0.32	0.19	4.45	0.89
3	28/12/23	2.88	0.27	0.32	0.40	0.00	0.24	4.11	0.82
4	1/1/24	3.36	0.22	0.21	0.34	0.16	0.27	4.56	0.91
5	3/1/24	3.52	0.26	0.24	0.35	0.00	0.37	4.74	0.95
6	6/1/24	3.68	0.32	0.18	0.50	0.18	0.35	5.20	1.04
7	10/10/24	2.72	0.26	0.26	0.45	0.16	0.00	3.84	0.77

Summation	31.55	6.31

The average solid waste generation for azadi are 6.31/7 = 0.9 kg/capita/d ,

Table (6) Solid waste component measured by researcher in iskan koya

No.	Date	Solid waste component (kg/d)						Total weight	Weight /capita
		food	paper	metallic	plastic	Glass	cloth and dust		
1	24/12/23	2.40	0.16	0.19	0.53	0.00	0.46	3.74	0.75
2	26/12/23	3.52	0.26	0.18	0.38	0.00	0.35	4.69	0.94
3	28/12/23	2.80	0.34	0.22	0.29	0.50	0.56	4.70	0.94
4	1/1/24	4.00	0.18	0.19	0.46	0.00	0.18	5.01	1.00
5	3/1/24	3.04	0.29	0.19	0.43	0.88	0.88	5.71	1.14
6	6/1/24	2.80	0.38	0.24	0.54	0.34	0.80	5.10	1.02
7	10/10/24	2.24	0.42	0.43	0.53	0.00	0.00	3.62	0.72
Summation								32.58	6.52

The average solid waste generation for iskan are 6.52/7 = 0.93 kg/capita/d,

The average solid waste generation for Koya are (1.1+0.9+0.93)/3= 0.95 kg/capita/d

that's mean the average near the no evaluated by koya municipality 0.986kg/Capita/d

The lowest proportion of urban populations and the lowest rate of waste generation range from 0.1 to 0.5 kg/capita/d in low-income countries [15].

For neighboring countries with similar socio-economic indicators, Countries with a GNP per capita of below $400 yield less than 0.5 kg/capita per day [15]. The per capita rate of urban waste generation is also rising from 0.5 to 1.1 kg per day, as GNP rises to the middle-income level. The most high-income countries, typically more than 1.1 kg per person a day, show the highest urban waste generation rates.

By comparison SW generation between high income and low-income centuries,

Table (7) shows the difference in these items between the developed and developing countries Data from nearby and other countries are presented in the subsequent sections [16].

Table (7), Typical Waste Generation Rates from a Number of Countries [16]

Category	Bangladesh (1999)	Pakistan (2001)	Indonesia (2001)	Thailand (2003)	United States (2002)
Amount of waste Generated	0.5	0.6 – 0.8	0.8 – 1.0	1.6	3.26

The lowest percentage of urban populations and the lowest rate of waste production [16] are in countries with low-income populations ranging from 0.1 to 0.5kg per day per capita.

The rate of urban waste production also rises per capita as GNP grows from 0.5 to 1.1 kg a day to medium-sized revenue. High-income countries generate the highest rates of city waste, generating more than 1.1 kg per person per day.

The estimated value of 0.986 kg/capita/d and 0.95 kg/capita/d for waste generation in Koya is reasonable when compared to similar cities, particularly in regions with comparable socio-economic conditions. However, the fact that low waste generation rates are reported could be attributed to the incomplete or inconsistent collection of waste in certain areas. As waste collection services expand and become more efficient, it is likely that these reported rates will increase, providing a more accurate reflection of the true waste generation levels.

Socio-economic factors play a crucial role in influencing individual waste generation rates, with the percentage of poverty in each district having a direct impact. Poorer areas tend to generate less waste due to lower consumption levels, while wealthier districts produce more waste, often linked to packaging and consumer goods. This variance highlights the need for more localized waste management strategies that cater to the specific needs and conditions of different districts.

One of the main challenges in waste management across many parts of the world is the lack of reliable, comparable data. Poor data quality can lead to inaccurate estimates of waste generation, which in turn affects decision-making processes related to waste management infrastructure and services. In the case of Koya, improving data collection and reporting mechanisms is crucial for developing a comprehensive waste management plan that can adapt to future changes in population growth, income levels, and other external factors.

4. Conclusions

Solid waste management (SWM) in Koya district presents a significant challenge for urban development as waste generation continues to rise. The estimated waste generation rates of 0.95 kg/capita/day by researchers and 0.986 kg/capita/day by the Koya municipality reflect the district's growing waste burden, which is projected to increase alongside economic growth. The adopted rate of 0.986 kg/capita/day assumes full waste collection across the district, resulting in approximately 121.7 tons of waste generated daily in 2019, with an annual total of about 44,420.5 tons. These generation rates are overall averages, with expected variations depending on factors such as district, income level, seasonal changes (notably fruit and vegetable waste), and time. Accurate waste projections depend heavily on reliable population estimates. Comparatively, Koya's waste composition and generation rates position it within the category of middle-income cities, based on studies from similar countries.

This study marks a pivotal step in addressing Koya's solid waste management challenges through the construction of an SW treatment plant in Koya, with the dual objectives of implementing the 4Rs (reduce, reuse, recycle, and recover) and generating power from waste. As urbanization and population growth increase in Koya, the volume of municipal solid waste is expected to rise, making effective waste management an essential component of sustainable urban development. Establishing a waste treatment plant will not only address the escalating waste problem but also contribute to broader environmental and economic goals by converting waste into valuable resources. And this initiative aligns with global trends toward circular economies, where waste is treated as a resource rather than a problem. In Koya's case, the successful implementation of a waste treatment plant could serve as a model for other cities in the region that face similar waste management challenges. Additionally, such a project would contribute to local economic growth by creating jobs in the waste management and energy sectors, further enhancing the social and economic benefits of the plant.

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