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# Assessment of Municipal Waste Management Practices in the Largest City of Pakistan Using GIS Technique: A Case Study of Gulshan-e-Iqbal Town, Karachi

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**ABSTRACT**

Rapidly expanding population of Karachi city has resulted in a number of solid and hazardous waste issues due to unsatisfactory policies, laws, political instability, and ineffective municipal administration. The primary objective of this study was to use geographic information system (GIS) technique for the evaluation of population density, waste generation, collection, and management of municipal solid waste (MSW). Present study revealed that the total volume of waste produced was correlated with rising population densities and improper collection of municipal solid waste from collection points. The MSW in Karachi city is managed through open air burning and waste disposal methods. It is observed that MSW is improperly collected from bins and transported by vehicles to the landfill sites. Small amounts of MSW recycling were carried out by the private sector, who pays off to Afghan waste pickers to transport waste from bins to dumping sites. Due to lack of proper training, workers use to scatter the waste all over the roads and around the bins. It is concluded that the waste is not being managed in a proper way and cutting-edge environment friendly technologies are essential for managing MSW issues, minimizing health risks, and preventing environmental degradation.

## Introduction

The exponential urbanization that is occurring worldwide brings a vast amount of solid waste with it, leading to a rapid increase in study of municipal waste management (MWM) worldwide (Wang et al., 2020). Waste Management encompasses everything done to regularly maintain a clean city, including waste collection and disposal, sewage treatment, water treatment, recycling, and health and hygiene issues. The best way to dispose the waste in separate containers for basic disposal and the integrated waste management (IWM) includes

several stages, namely, (i) collection and sorting of waste, (ii) reuse and recycling of waste, (iii) recovery from the waste, and (iv) final disposal of the waste. Sorting and segregation of waste helps to similar types together and make the treatment process efficient (Sondh et al., 2024). The treatment of hazardous waste is one of the most serious problems that a growing city faces. Effective waste management is currently a major challenge for metropolitan areas (Abbas and Small, 2014). In recent years, blasting populations, advancements in infrastructure, changes in way of life, and growing trends of urbanization have altered the rate of age and amount of solid waste (Paracha, 2014). It is well established that the pollution of the environment and the spread of infectious diseases such as more mosquitoes and rats increase the risk of illness malaria and dengue which caused by improper solid waste management (Chisanga et al., 2024). Similarly, there is a strong relationship between solid waste generation and the population density.

Karachi is the second-largest Muslim city in the world and Pakistan's best metropolitan center with approximately 24 million residents (Cox, 2014; Paracha, 2014). It is also regarded as Pakistan's business hub because it is on the southern coast. Since 1970s, Pakistan has revealed a pattern of rapid urbanization, with massive movement of population from all the provinces to this city in search of better business opportunities (Sharif and Raza, 2016). Solid waste production in Karachi increased from 2000 tons per day in 1974 to 6000 tons per day in 2001(Ali and Hasan, 2000) followed by 9,000 tons per day in 2005 (Zaheer, 2007). The current rate of 12,000 tons per day is staggering (Mahmood, 2019). The massive migration, which began in 1947, continued until the start of war on terrorism in 2001. Karachi witnessed an unprecedented influx of Afghan refugees, mirroring the situation of the 1979 Afghan-Soviet conflict. Karachi has always been able to keep up with the rapid growth of its population. Five massive migrations have occurred in the city, including internal displacement. This led to exponential rise in the municipal waste generation. To mitigate waste problem, we should need to care about people's needs and economy (Guo et al., 2021).

A city's ability to plan settlements and manage the resulting municipal solid waste becomes extremely difficult if the growth spurt occurs on a consistent basis. According to statistics, Karachi alone generates approximately 12,000 tons of solid waste each day, of which forty percent is dumped on the streets which leads to rise in disease and make the environment pollutes and this because of rapid population growth and inadequate infrastructure (Sabir et al., 2016). The residents of Karachi contribute to the growing problem of waste through activities like illegal dumping. As the proportion of solid waste in the urban center continues to rise on a daily basis, significant changes must be made immediately. As a result of solid waste covering bridges, roads, and localities, waste management in Karachi is currently at its worst. Under the "Act of Sindh Assembly," the Sindh Solid Waste Management Board (SSWMB) was established in 2014 that oversees the management of Karachi's solid waste, which was previously managed by Karachi Metropolitan Corporation (KMC) and 13 other districts.

Due to a steady rise in extras, solid waste the board presents a significant challenge for local states. Karachi is governed by a city-regional government and is broken up into six locales and 18 sub-locales, or tehsils. 178 association gatherings oversee strong waste in each tehsil. These gatherings are administratively isolated. The strong waste administration framework in Karachi is managed by two cantonment sheets under the City District Government Karachi (CDGK), which include the Region Civil Partnership (DMC) and Karachi Metropolitan Enterprise (KMC). Present study focused on constrains that the authorities' in charge face and how the municipal waste management process is carried out in Karachi. The medium of observations and software like Arc GIS were used to collect data for this qualitative study.

## Materials and Methods

### Study design

The solid waste management systems have been evaluated in this study using both quantitative and qualitative data. The information

was acquired from a variety of sources, including websites, newspapers, printed materials, books, and government agencies. MSW (CDGK) was used to identify ground reality photographs, which may have significant importance for this investigation. To deal with the situation of MSW management, vehicles and the MSW collection are essential. For the purpose of their analysis, the method based on spearman's rank correlation coefficient was used. Population and the production of waste are closely linked to one another to establish the relationship.

The populace thickness was determined in this study by utilizing ArcGIS 10.5. First, the area was calculated using a geometry calculation tool and subsequently the population density was calculated using the formula given below. These are some very important steps that were taken to calculate the population density.

**Population Density= Population/Area (sq. km)**

**Study area**

Karachi is a huge city that plays a big role in the economy of Pakistan. It is in the province of Sindh and has the following latitude and longitude of Karachi: 24˚54'20.16''N, 67˚4'55.92''E. Besides, it has been partitioned into five locals viz., Districts Malir, Karachi East, Karachi West, Karachi Central, Karachi South. In the Karachi East district of Karachi, Sindh, Pakistan, Gulshan-e-Iqbal is a large residential and commercial neighborhood for the middle class to upper middle class (Blocks 15, 16, 17, and 18). Prior to its dissolution in 2011, it was managed as part of the Gulshan Town borough. The Pakistani national poet Allama Muhammad Iqbal is the subject of the name "Gulshan-e-Iqbal," which translates to "the garden of Iqbal." It has beautiful gardens.

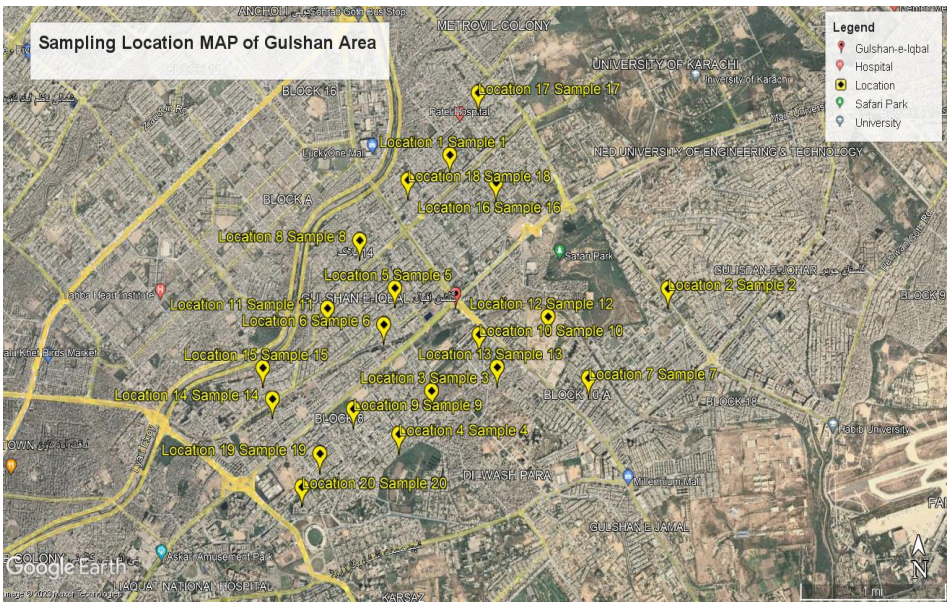


**Fig. 1** Sample location map of study area.

## Results and Discussion

### Waste Related Variable

#### *Dependent variables*

The daily amount of waste produced (in tons) is the study's dependent variable. The data of waste generation per day (ton) during 2019 from various towns of Karachi were used for the analysis.

#### *Independent variables*

Population and the production of waste are closely linked to one another. Population density was calculated using the formula above.

#### *Population density calculation through ArcGIS:*

With a significant increase in the number of people living there, the multicultural city presents the issue of accumulating waste. On the other hand, the city has not been helped by the increase in population, which has resulted in unorganized conditions for residents. ArcGIS 10.5, a method for calculating population density, was used in this study to address this circumstance for the analysis of population density.

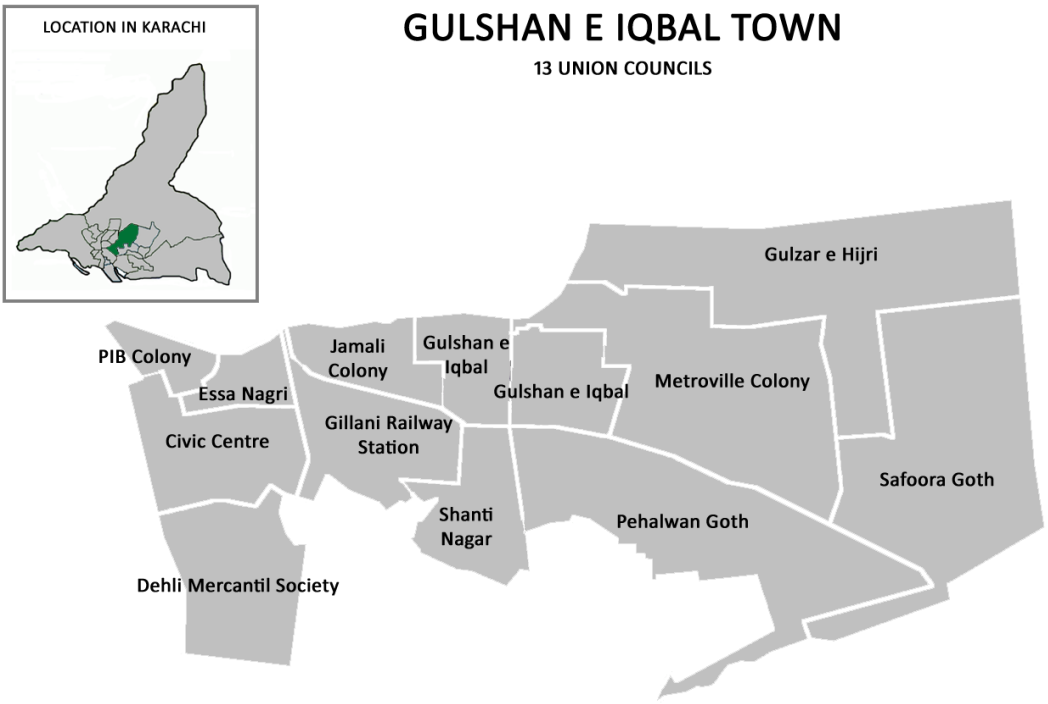


**Fig. 2** showing administrative map of study area with 13 union councils.

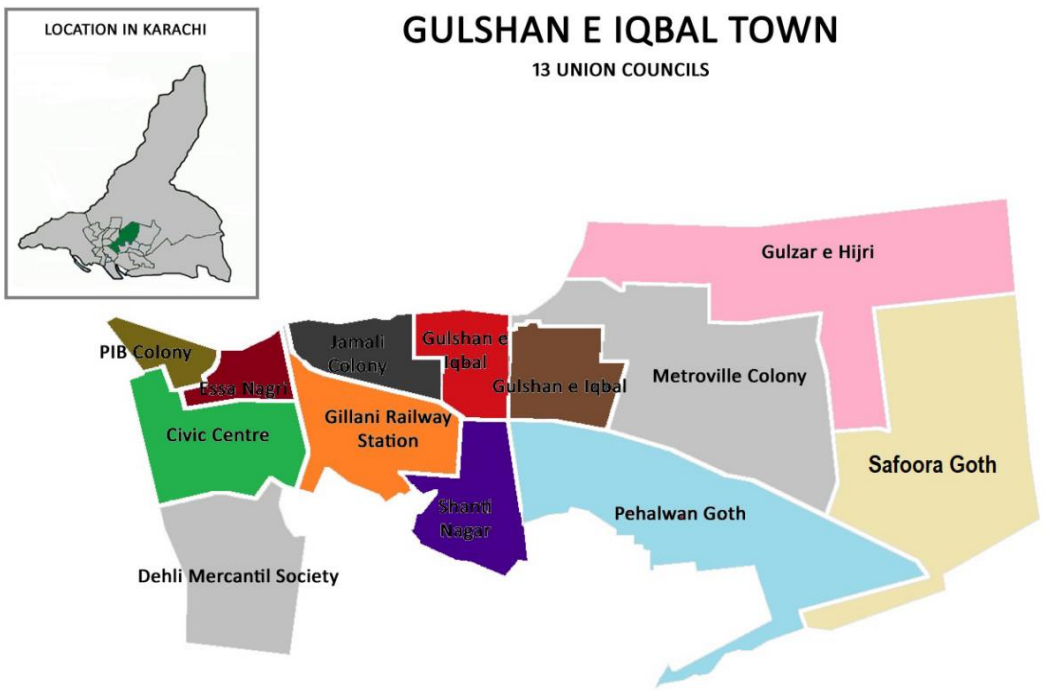


**Fig. 3** population density map of study area.

**Table 1** Area, population and population density in union councils of Gulshan Town.

| S. NO. | UNION COUNCILS | POPULATION | AREA (km) | POPULATION DENSITY (sq.km) |
|---|---|---|---|---|
| 1 | Civic center | 89,170 | 3.69 | 24,165.311 |
| 2 | Delhi mercantile society | 70,704 | 4.20 | 16,834.285 |
| 3 | Essa Nagri | 96,405 | 1.10 | 87,640.909 |
| 4 | Gillani railway station | 87,606 | 3.60 | 24,335 |
| 5 | Gulshan-e-Iqbal I | 87,606 | 3.60 | 24,335 |
| 6 | Gulshan-e-Iqbal II | 61,104 | 2.25 | 27,157.333 |
| 7 | Gulzar-e Hijri | 63,973 | 9.00 | 7,108.111 |
| 8 | Jamali colony | 64,647 | 1.42 | 45,426.056 |
| 9 | Metroville colony | 99,234 | 8.61 | 11,525.435 |
| 10 | Pehlwan goth | 65,044 | 10.22 | 6,364.383 |
| 11 | PIB colony | 57,224 | 0.90 | 63,582.222 |
| 12 | Safoora goth | 64,608 | 4.07 | 15,874.201 |
| 13 | Shanti Nagar | 66,371 | 2.20 | 30,168.636 |

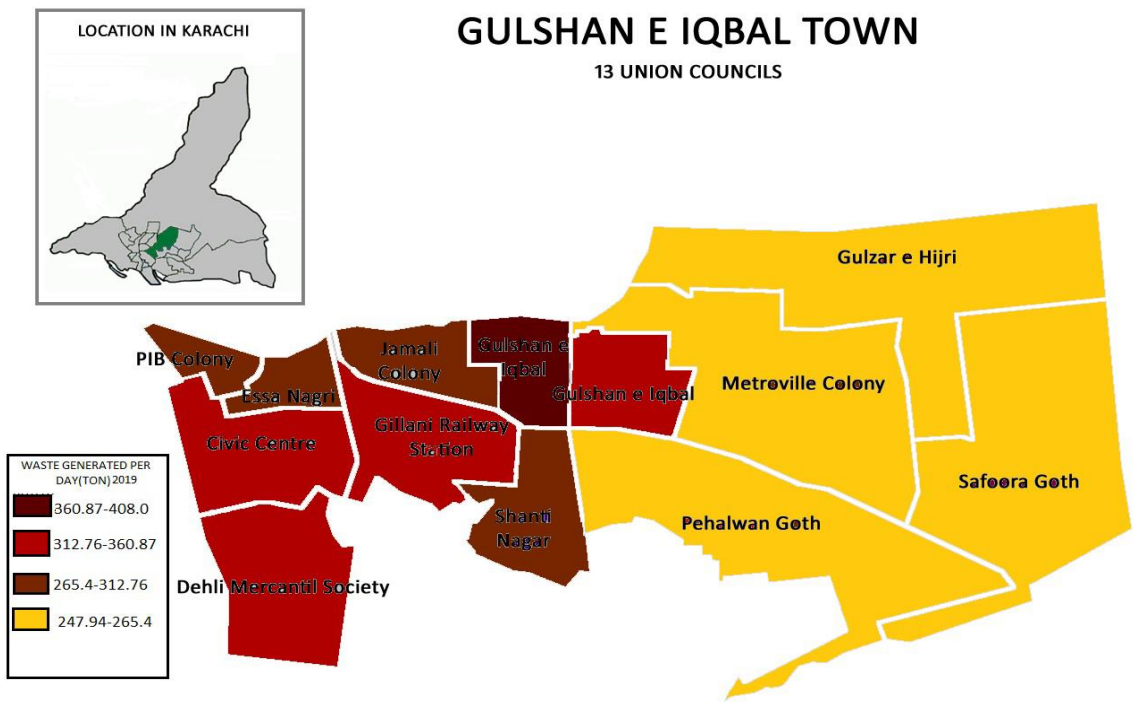


**Fig. 4** Map showing waste generation per day in 13 Union councils of Gulshan-e-Iqbal Town.

Figure 3 shows the population density of union councils of Gulshan town. Gulshan e Iqbal I, II, Essa Nagri, Gillani railway station, PIB colony, Safoora goth, Shanti Nagar and Civic Center are representing dense population, whilst Table 1 revealed apparent facts regarding population, area, and population density in dissimilar UC's of Gulshan town. The Per capita

MSW generation in the Karachi was 0.5 kg per person per day and approximately 2929402.293 tons per year whereas, in Gulshan town the waste generation is 408.0 ton per day. It is anticipated that an increase the MSW generation has significant correlation with dense population. As shown in Fig. 4 indicated that the clear facts about the waste generated rate of Gulshan town, Gulshan e Iqbal II, Essa Nagri, Gillani railway station, PIB colony, Safoora goth, Shanti Nagar and civic center which represent the highest value in the given map. Our study area which is mostly incorporated in Gulshan-e Iqbal I and II, which is a highly populated area of Gulshan town as shown in (fig 3) is a clear indication towards that population is directly proportional to waste generation the higher the population there will be more wastage.

(a) Piling up of waste

(b) sorting reusable items

(c) Waste burning along the road.

(d) A heap of waste in a barren plot.

**Fig. 5** shows (a) waste pile, (b) sorting of reusable collection (c) waste burning (d) open waste dumping.

**Table 2** showing general composition of type of waste in Gulshan.

| General Composition | Typical Composition | Specific Composition | Recyclable Materials |
|---|---|---|---|
| **ORGANIC** | Biodegradable material | Food and vegetables | Recyclable |
| | Paper and cardboard | Paper and cardboard | Recyclable |
| | Plastics | HDPE, LDPE, PVC | Recyclable |
| | Clothes and fabrics | Leather, rubber, fabrics | Recyclable |
| | Garden waste | Leaves and grass | Recyclable |
| | Wood | Wood | Recyclable |
| | Organic wastes | Bones | Recyclable |
| **INORGANIC** | Metals | Cans, aluminum | Recyclable |
| | Glass | Non-colored, colored | Recyclable |
| | Soil and ashes | Soil and ashes | Recyclable |
| | Non-classified materials | Voluminous objects | Recyclable |

The table (2) shows us the type of waste in Gulshan its general and typical composition and whether it is recyclable or not. We may be a highly wastage zone but by knowing that 90% of Gulshan's waste is recyclable there is a light hope where we can alter our present situation. Instead of just burning waste in residential areas and causing tremendous amount of pollution we can recycle and reuse items in whatever means necessary. There should proper organization made for this purpose that can work on proper dumping, recycling and reusing of these wastes. This study has highlighted the issues faces municipal solid waste system in a multicultural city, assessment has been done through GIS Techniques statistical analysis of two variables have done, a positive correlation has found between population and waste generated rate per day (tons). Solid waste management is a problem for every society, but it varies according to the respective history, socio-cultural values, population, and political situation. There should be more transparency between the masses and the government as public doesn't have easy access to the information about either the factors or steps taken by the government. Computerized and manual data should be kept for the functioning of the government properly and it will help future governments as well for they can be aware about the projects as well. Discussion with the KMC officials showed that no computerized data is kept as record. Relevant employees should be hired to make work more effective. Educational institutes play a vital role in this sector for they can help motivate their students to recycle and undertake garbage collections through different activities and volunteer programs. For example, agricultural waste can be recycled through four ways, out of which, two can be done in households like the use of vegetable biomass as a fertilizer/compost for the production of vegetables and fruits; and it can also be used as food for livestock. The other two methods can be espoused for energy production and chemical products' production (Maria et al., 2005).

## Conclusion and Recommendations

Present study revealed that the total volume of waste produced was correlated with rising population densities and improper collection of municipal solid waste from collection points. The MSW in Karachi city is managed through open air burning and waste disposal methods. MSW is improperly collected from bins and transported by vehicles to the landfill sites. Small amounts of MSW recycling were carried out by the private

sector, who pays off to Afghan waste pickers to transport waste from bins to dumping sites. Due to lack of proper training, workers use to scatter the waste all over the roads and around the bins.

It is concluded that the waste is not being managed in a proper way and cutting-edge environment friendly technologies are essential for managing MSW issues, minimizing health risks, and preventing environmental degradation. The collection and disposal of waste must be streamlined by developing and implementing a more unified strategy for solid waste management. Additionally, Karachiites need to be educated on how to encourage practices like recycling to contribute to the reduction of solid waste.

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