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Economic Assessment Of Municipal Solid Waste Management Programs: A Comparative Study Of Indore And Rohtak

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ABSTRACT:

Municipal solid waste management (SWM) is commonly understood to entail the collection of solid waste and its proper disposal through established routes or agreements with other parties. However, the meaning of MSWM varies from nation to nation worldwide, depending on the context and environment of the situation. For instance, trash that is regarded as general waste is referred to as "solid waste" in countries like Singapore and Japan. However, Singapore is considered when talking about the classification of general rubbish, not Japan. This is because of the industrial waste component. Parallel to this, different countries define municipal solid waste management (MSWM) in different ways, which makes it difficult to come up with a single, consistent definition that applies to every country. This article's goal is to compare the waste management practises of two Tier-II Indian towns, respectively, Rohtak and Indore. In the Ministry of Housing and Urban Affairs' most recent Swachh Survekshan, which was conducted as part of the Swachh Bharat Abhiyan (Urban), Rohtak is placed 372nd, whereas the latter is ranked first. This article aims to determine the steps that Rohtak needs to do to improve its status as one of India's cleanest cities and to highlight the key aspects of Rohtak's garbage management that need improvement, using Indore as a point of reference.

Key words-*:* MSWM, Economic, Environment.

1. INTRODUCTION:

In contemporary society, solid waste refers to the waste products of human activity, such as the production, consumption, and distribution of various goods. Both industrialized and developing nations have investigated a wide range of topics, including innovation, technology, and recycling in municipal solid waste management. These kinds of themes have been the focus of several investigations. Few research have been done on the economic analysis of managing municipal solid waste, particularly in developing countries. This is especially true for the costs and revenues associated with solid waste management. For the most part, the municipal corporation lacks accurate statistics regarding the production of solid waste, its collection, transportation, and ultimate disposal. Economists find the solid waste management economic assessment to be complicated for this reason. Economic analysis of municipal solid waste management is also found to be the most helpful by local policy makers in a number of areas, such as the development of municipal waste management fees, taxes, or subsidies; the benefits and drawbacks of converting waste into energy; and the identification of urban property through the improvement of environmental amenities. For instance, the National Institute of Urban Affairs claimed that the cost of solid waste collection and disposal was Rs 135 per ton, whereas a research by the National Solid Waste Association found that the cost of municipal solid waste management was Rs 417 per ton. These are only two examples of the many economic estimates that have been done regarding the cost of managing solid waste in Indian cities. Thus, in a number of developing and industrialized nations, this study has looked into the economics of municipal solid waste management and public policy at the municipal level.

1.1. Economics of municipal solid waste management

When it comes to the examination of the procedures for managing municipal solid waste, Harisch was the first author to greatly enhance the technique. Focus then turned to the second wave of research, with special attention to the contributions of Stevens, who significantly modified the Hirsch Model, and Dubin and Navarro, who made important methodological advances. Don Fullerton, Beede, Bloom, and Thomas Kinnaman had all introduced new techniques and applied generational advances to the task of conducting an econometric analysis of municipal solid waste management. Last but not least, it should be mentioned that a number of research projects conducted in India have employed cutting-edge methodological advances and approaches, particularly those that have increased their use of statistical methodology. Consequently, this section has given careful consideration to more recent findings.
The first empirical study to utilize econometric analysis to investigate whether the mode of service delivery—public versus private—had an effect on municipal costs, among other things, was Hirsch's study, which looked at a sample of

24 communities in St. Louis Country, Missouri. The location of the study was in Missouri. However, an econometric model was used to determine the explanatory factors in this study, and the data used was restricted to the accessible data from the 1960s, the year the pertinent material was obtained. Therefore, the variables that were ultimately used to explain cost (the average costs per service) were the number of waste collection locations, the frequency of weekly collections, the type of service management (private vs. municipal), the residential area, the funding sources, the frequency of weekly collections, and the distinction between private and municipal delivery. The article's conclusion was that, in terms of the service's monetary value, the private and municipal distribution systems differed significantly.
The findings of this investigation demonstrated that there were no scale economies in the provision of the service. Hardy and Greission investigated ways to reduce the cost of collecting and disposing of solid waste by collaborating. These naive algorithms quickly identified the optimal locations for landfills and the best routes for collection trucks to go throughout the study area, which consisted of five different countries. They discussed the challenges that rural areas face in delivering public services in order to determine which approach to municipal solid waste management would be the most economical for the locations that were selected. They explained that population density and service area size determined the economies of scale that could be achieved in the disposal stage of a municipal solid waste management system. The cost of gathering was estimated using this information as well. Once the overall costs of collection and disposal were verified, the regional approach might be effective for the research sites. The approach that uses the regional landfills in each of the five countries has the lowest total cost. It was projected that the system would cost $519,815 annually if each county operated it independently. Nevertheless, the $447,275 annual actual costs were significantly less than that. According to this economic analysis, the cost of establishing a regional system for gathering and disposing of solid waste may be justified.
Kumar et al. state that from 2007 to 2024, forecasts were made using the fuzzy regression method. Research shows that it's critical to identify and sort waste materials in order to ensure the operation of reuse-recycle treatment facilities and availability of suitable garbage disposal sites. The study's fuzzy regression coefficient was built using historical data on solid waste categories (paper, plastic, food, metal, glass, and other wastes), per capita income, GDP, total population, density, and the number of people living in each household. As a result, the link between the two variables was examined. There were predicted changes in waste composition based on fuzzy regression analysis. For example, from 2007 to 2024, the percentage of paper trash was expected to decrease from 29.50 percent to 24.58 percent, while the percentage of food waste was predicted to reduce from 36.37 percent to 27.55 percent. On the flip side, researchers predicted that plastic will account for an increasing proportion of trash, rising from 2.74 to 3.55%. Compared to where things stand now, the percentage changes in metal and glass cases were expected to be the biggest. Expectations were that the percentage changes would be three times and twice as high as the current levels, respectively. One way to help the environment would be to establish a dependable garbage collection system, therefore Maria Eugenia Ibarraran Viniegra set out to determine how much people are ready to spend on this matter.
Located north of Atlixco and west of Pueble, the Municipality of San Pedro Cholula was the primary focus of the study. In San Pedro Cholula, it utilised econometrics to determine what factors impact people's willingness to pay for environmental quality. An estimated 150,000 individuals called this 712 square km home. The bulk of those involved in allied activities were farmers, making up 36.5% of the total. People working in the arts, crafts, and labour sector accounted for 14.5% of the total, while 8.3% were entrepreneurs. The average monthly contribution that households were willing to make to the project was $1.85, according to the poll. The association between age and willingness to pay was significant, and it was found to be inversely proportional to the age component. The correlation between environmental ethics and people's desire to pay suggests that the two do not coincide with one another in terms of people's interest in environmental quality. One possible explanation is that they were afraid the cost of rubbish collection would go up if they were to reveal their actual willingness to pay. Finally, they had made it possible for developing countries to make better-informed investment decisions by promoting the idea of recognising the significance of environmental quality.

Objectives

1. Examine current municipal solid waste management initiatives from a cost-benefit perspective.
2. Assess the initiatives' effectiveness in creating jobs and their economic feasibility.

LITERATURE REVIEW:

Verma, A et al. (2014) Quick population expansion has led to an increase in the need for municipal solid waste (MSW) management services in urban areas. In modern cities, this is now standard operating procedure for the Municipal Corporation and similar municipal institutions. Additionally, there is a lack of space, the complexity of the trash that is produced, and the rapid rate of municipal solid waste generation, all of which require almost as much focus. Indore is two things: the most populated city in Madhya Pradesh and the commercial hub of the state. The current population is

24,730,27 lakhs. While efforts are underway to provide infrastructure for sustainable growth, it is as important to manage municipal solid waste. In contrast, collecting and analyzing data for a study on urban MSW management by hand is a huge pain due to the large number of statistics needed. The outcome is that the system needs to be computerized. One technological solution that emerged to alleviate this problem and facilitate better, more controllable waste management planning was the Geographical Information System (GIS). The implementation time is likewise minimal. Much less work will have to go into waste management because of this. This study's overarching goal is to provide light on how Indore's solid waste management system handles the many stages of garbage creation, accumulation, transportation, treatment, and disposal. while keeping in mind the requirements of the Municipal Solid Waste Rules, 2000, to examine Indore's present MSW handling extensively. also to propose a GIS-based approach to managing SWM in metropolitan areas. Applying the produced model to the region's analysis is crucial for addressing current issues like optimizing waste transportation routes, planning the location of waste disposal facilities, and distributing garbage bins appropriately. In this study, we see how the Geographic Information System can help with MSW management decisions. By using this technique, the study area's solid waste can be more easily eliminated. Implementing a systemic change rooted in a Geographic Information System model has the potential to alleviate some of the challenges linked to MSW management in the area under study while also reducing the overall labor intensity of waste management.

Jha, B., and Saifi, N. (2023) Garbage management is one of the biggest problems that contemporary civilization is facing. As a result of cities' ever-increasing populations, managing MSW has become an essential service. Municipal corporations and urban local bodies are obligated to decrease solid waste in an effective manner. The majority of urban local bodies (ULBs) lack the necessary infrastructure, resources, education, and personnel to manage the massive amounts of solid waste that are generated in metropolitan areas. Some of the main obstacles are sorting waste at the source, collecting trash at the curb, chances for recycling and reuse, treatment technology, land availability, and disposal knowledge. Indore, Madhya Pradesh, was named India's cleanest city in August 2020 by the Swachh Survekshan programme. Indore City's solid waste management has been an integral part of the city's success, and this study intends to investigate its present condition. Additionally, this research looked at the methods used by Indore to attain a 100% segregation rate, such as door-to-door collection, public education, effective transportation, garbage vehicles equipped with GPS, and subsequent processing. A literature review served as the basis for this investigation. Scholars, NGOs, and municipal officials in other developing nations and big urban areas may find this study's conclusions interesting.

Arora, A., and Wagle, S. (1921). As of late, India's public sector has been largely ignored when it comes to managing municipal solid garbage (MSWM). Therefore, the towns that are growing the fastest are being overshadowed by garbage dumps that have been left out in the open. The majority of written material about the municipal solid waste management business talks about different technological and administrative problems as major issues. Although this piece does look at things from a policy point of view, it focuses on activities in the sector's "last mile." With this study, we want to find out what role front-line workers play in collecting and transporting solid waste in the last mile of the city of Indore, which went from being ranked 149th in 2014 to first in a national survey of cleanliness in 2017 and then stayed at the top of the rankings in both 2018 and 2019. In its conclusion, the piece stresses how important it is to make many changes to the way human resource management (HRM) is done in the city of Indore. Reforms include a strict system for keeping track of attendance and making working processes more organized in the last mile of operations. To support these changes, special tactics were used to make sure that people and front-line workers were responsible. Additionally, important players from the old scheme were added. Overall, these efforts have helped Indore become and stay the cleanest city in the country.

3. MATERIALS AND METHODS

Managing solid garbage has always been a big social and environmental issue in a country like India, and it's become even more important in recent years. Over the past few years, the amount of solid trash being made across the country has increased significantly. This trend is most noticeable in the country's cities. Since its founding in 1991, India has gone through a lot of changes. Fast development, which has been caused by fast population growth, has sped up this change. Because of this, people have been changing their eating habits and other parts of their lives to adapt to changes in their quality of life (Malviya et al. 2002). SWM management was already having a tough time, and all of these behaviors have made things even more stressful for them. The business is having a hard time because it doesn't have enough money, the technology it uses isn't right, and people don't care about municipal solid waste. Because of these things, the country has a big problem and is under a lot of pressure to solve this social and environmental problem, which is mostly the job of the local governments (Aich & Ghosh 2019).
Things that could be broken down by living things used to make up a lot of trash in cities. People didn't buy as much stuff, and they didn't use a lot of products like plastic. It didn't really bother the communities because the waste was reused or recycled through composting, and it was then used as manure by farmers (Ravi & Vishnudas 2016). There was an

increase in the amount of plastics and other non-biodegradable materials in municipal trash after more of these materials were used in manufacturing and packaging. These materials got into the suburban farming community because of careless garbage management. There, they started to hurt the farmers and growers. One of the most important things to think about when dealing with this problem is how people use technology and how they act around others in general. Before you deal with this problem, there are many other things you should think about. Management of local solid waste management (SWM) depends on how people feel about trash in general. The process of fixing this problem is what regulated waste management is built on. Indians usually think that it is the government's job to get rid of all the trash that comes from all kinds of businesses. Many people agree with this. It's both scary and sad how this case is being treated. In order for the system to work, people need to realize that they are the only ones who can properly deal with the trash that is made. The people in charge of cities and towns have to make sure that their solid trash management systems work well and don't hurt people too much. Ganesan (2017) says that technological progress has led to the creation and use of a centralized waste management system in already-established industrial cultures like Europe and North America.

Municipal solid waste management (MSWM) in India is calculated in accordance with the rules that were enacted in 2000 and 2016, respectively, for managing such trash. In an effort to reduce garbage pollution, local governments were tasked with the difficult task of collecting, processing, and disposing of solid waste in accordance with the Municipal Solid Waste Management Rules of 2000. An organised strategy for trash disposal was required by this system. The Solid Waste (Management and Handling) Rules, 2016 modification was a break from the SWM rules 2000; it tackled the problem of unchecked centralised waste management procedures employed by local governments. The new rules highlighted the benefits of a circular economy by increasing the focus on source segregation and correct waste treatment through increasing the chances for recycling and reusing. According to a study conducted in 2020 by Rathore and Sarmah, the circular economy in MSW management was investigated for its social, environmental, and economic feasibility. The primary concern of the research was the feasibility of anaerobic conversion of collected organic solid waste into biogas, which could then be used to fuel a thermal power plant. Thus, thermal power plants that generate electricity through the combustion of coal will become less important overall. The proposed method has been shown to lessen the monetary, social, and ecological expenses associated with MSW management in Bilaspur, India. Everything was made feasible because of how well it was executed. Megacities have been the focus of studies on community-based initiatives for sustainable integrated waste management, but more study is needed to fully grasp its potential, as its actual implementation will depend on the specific social obligations of those groups (Colon & Fawcett 2006).

Kerala underwent a shift in its waste management strategy, going from a centralized to a decentralized one, a long time before the state's SWM rules were changed in 2016. The state is thought to produce 3,410,243 metric tons of solid trash annually. Because of its municipal solid waste management experience, the state has had a significant influence on changes made to the laws governing waste management across the country. The state's commercial center, Rohtak, is where the majority of the rubbish created is produced. The city has been experiencing issues with its municipal solid waste management (MSWM) during the past few years.

The main goal of this article is to find a municipal solid waste management project that is both technically and financially feasible for the city of Rohtak by doing a comparison study with the city of Indore. It should be possible to carry out this project in stages. The objectives of this study are specifically as follows:

- To draw comparisons between the waste management practices of the Municipal Corporations of Rohtak and Indore.
- To emphasize the strategies implemented by the two cities.
- To determine Rohtak City's problems and how the Indore Municipal Corporation's (IMC) present initiatives can help the city

The daily garbage output of the city of Indore exceeds 1115 metric tons, and all solid trash generated, whether from residential or commercial buildings, is collected at the source. After starting as a test project in January of 2016, door-to-door trash pickup services were launched in 2016. The city's aim of providing door-to-door services for the collection of all waste was accomplished after a year. By continuing its efforts and forming alliances with other residential and commercial entities, the city has also achieved 100% garbage segregation. The residents of Indore were instrumental in keeping the city neat and clean, and without their efforts, none of this would have been possible (Mokale 2019). This has led to worries among municipal planners as Rohtak has grown significantly over the past decade and continues to push its boundaries. It is one of the cities in India with the highest concentration of high-rise apartments, which adds to the quantity of waste generated. A number of challenges would have to be faced by the city as a result of poor upkeep of the roads and drainage systems, as well as poor management of the Municipal Corporation's municipal solid waste management. Correcting these issues will require a substantial financial outlay if it becomes a metropolitan area (Ravi & Vishnudas 2018).

Table 1: Projected population and total residential waste growth per day for Rohtak and Indore.

Year	Rohtak			Indore		
	Population	**Per capita waste generated* (kg)**	**Total waste (Tons)**	**Population**	**Per capita waste generated* (kg)**	**Total waste (Tons)**
2001	595575	0.518	308.51	1626297	0.321	522.04
2011	601574	0.518	311.62	2104658	0.321	675.6
2021	628645	0.518	325.64	2681831	0.321	860.87
2031	656934	0.518	340.29	2912701	0.321	934.98

Table 2: Projected total increase per day in the share of different solid waste materials for Rohtk and Indore in tonnes.

Solid Waste Material*	Rohtak			Indore		
	2011	2011	2021	2031	2021	2031
Paper	2.52	5.47	6.97	7.57	2.64	2.76
Glass waste	1.37	2.97	3.79	4.11	1.43	1.5
Metal waste	1.99	4.32	5.51	5.98	2.08	2.18
Organic Waste	136.96	296.93	378.35	410.92	143.12	149.56
Plastic waste	1.93	4.19	5.34	5.8	2.02	2.11
Stones, ashes	130.29	282.47	359.93	390.92	136.15	142.28
Miscellaneous	36.55	79.25	100.98	109.67	38.2	39.92

3.1. Population

Even though the city's population is increasing, census studies show that the ecological footprint of waste generation in Rohtak's residential areas has been analyzed. If the current trend of managing municipal solid waste is maintained, the city will need an area by the year 2050 that is equal to its current size. The Gathering, Elimination, and Handling of Waste. The numerous sorts of solid waste that are created are shown in the accompanying table, together with an estimated quantity of each type in the next ten years. The values provide an appropriate way to quantify the importance of segregation and the consequent smooth operation of the system.

3.2. Rohtak

Nearly half of the city's residents live in apartments in high-rise structures, while over half have single-family homes. This style of home got its start since most single-family homes have a system in place for dealing with garden trash. This means that residential areas rely entirely on SWM's waste treatment services. Land availability and treatment methods that do not promote environmental sustainability result in ineffective waste management. The kind of housing and the technique of waste storage play a vital role in the effective implementation of a system for managing municipal solid waste.

There are primarily three methods that households utilise to deal with waste:

- Household treatments like composting or burning
- Non-governmental organisations or self-help groups
- Street discards

Residents of Rohtak can now take advantage of door-to-door pickup services offered by the Kudumbashree and the Municipality. These services are available for both single-family homes and multi-unit buildings. Kudumbashree only encompasses fifteen of Rohtak City's seventy-one wards. This is valid regardless of whether Kudumbashree receives universal praise for its effectiveness. Residents' propensity to partake in non-sustainable practices, such as trash burning and street dumping, is exacerbated by the unsatisfactory service delivery by municipal staff in the remaining wards, households' unwillingness to pay the user fees for door-to-door waste collection, and the availability of land. The high rate of trash dumped onto streets without being separated into different types is another big problem with waste management. Even city workers will be required to transport unsorted garbage to designated locations. Polythene bags are commonly used by households that choose to dispose of their waste in the streets. This bag is perfect for disposing of both biodegradable and non-biodegradable waste. Using low-quality polyethylene bags affects both the total degradation process and the treatment's effectiveness. According to Sebastian, Kumar, and Alappat (2019), these trashes contain a mix of recyclable polymers, organic compounds, and plastics that have not been sorted. In addition, these contaminants end up piling up in landfills. Municipal solid waste management (MSWM) and the environment are both severely impacted by plastics.

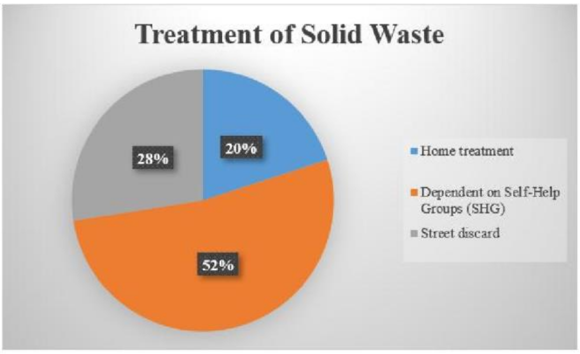

Fig. 1: Waste Treatment Methodology adopted by Rohtak Households.

Transporting 40% of the generated garbage to the facility for treatment is the responsibility of the city. The door-to-door collection operation in Rohtak is supported by approximately 250 resident associations, Kudumbashree self-help workers, and city staff respectively. A number of groups lend their support to the proper authorities. After the main garbage collection—which requires the use of hand carts, wheelbarrows, and tractor trailers—there are twenty-one sanitation circles spread out over the city. Colllecting trash for disposal is the job of these groups. A fleet of 107 vehicles, consisting of tippers, tractor-trailers, and other trucks, transports garbage from secondary collecting points to the ultimate treatment facility. Such a fleet of vehicles is responsible for refuse transportation.

Numerous divisions exist within the city of Indore, which is structured with 85 wards and 19 zones. Six thousand dwellings and a plethora of businesses make up each ward. On top of collecting garbage from residential, commercial, and industrial producers, the city is also in charge of collecting garbage from any and all other sources. For residential and flat waste, a door-to-door service is used; for semi-bulk and complete bulk producers, bulk collecting systems are employed. Thanks to these methods, the city can guarantee full collection from these wards and cover all wards.

Counting the amount of garbage produced daily allows us to categorise the Indore waste producers. These generators are categorised into three groups: bulk, semi-bulk, and household. The garbage we generate is always sorted into several groups, and then further subdivided within each group. Table 3, which can be found online, provides a detailed breakdown of the waste producers' classification. Partitioned tippers, or Nigam trucks, gather the garbage that homeowners have divided and sorted. Each generator creates a wide variety of waste, thus these vehicles have various chambers to handle it. In building the chambers, three separate ratios were used: 50:50, 60:40, and 85:15. As a function of both area and garbage created within the area, these ratios are defined. Each processing plant has an automated weighbridge, which is the first point of contact for garbage trucks that stop by to drop off their loads. In order to identify the waste kind, the vehicles are weighed both when they arrive and when they are unloaded. After the assignment is finished, an invoice is created and sent to the facility. This receipt contains all the information regarding the trash that was delivered, including the type, amount, and origin of the trash, as well as the specifics of the vehicle and the time of delivery. For further processing and separation, all of the dry wastes are transferred to the Material Recovery Facilities (MRF) facilities. The bulk producers and GTS send their wet waste to the central composting facility, where it undergoes further processing. After being transported in specialised biomedical vehicles from GTS to an independent facility, domestic hazardous waste is then offloaded. The Common Biomedical trash Facility (CBWTF) collects and burns all of the home hazardous trash. Hence, eight cutting-edge garbage transfer facilities have been built by the Indore Municipal Corporation to enhance its secondary collecting procedure. Overall, this has reduced the expenses of the transportation system and the secondary collection system. The corporation processed all of the waste it generated, transforming it into a product.

Table 3: Classification of waste generators in Indore.

Waste Generators	Amount/ Day	Segregation
Domestic	< 25 Kg	Wet, Dry, and Domestic Hazardous
Semi-Bulk Generators	25 - 100 Kg	Wet and Dry
Bulk Generators	> 50 Kg	Wet and Dry

A boundary wall was constructed, and sixty thousand seedlings were planted in the area that had been used for trenching, thereby establishing the garden. To become their own success stories, other municipal corporations could look to the Indore Municipal Corporation (IMC) as an example of what may be accomplished. In the past, the location was hideous for the locals due to the continual smoke and fire it produced. We owe the Indore community our deepest gratitude for all that they did to make the system a success. An existential threat posed by MSWM was an issue in Indore, as it was in many other Indian towns. Chauhan et al. 2020 states that the Information, Education, and Communication (IEC) department is projected to play a significant role in establishing a Swachh Bharat Mission in Indore. It was the mission of the International Emergency Committee (IEC) to induce the necessary mental shift in behaviour among all parties involved, ranging from citizens to government officials. They advertised cultural events through street plays and wall paintings, utilised mass communication strategies like social media campaigns and FM stations to disseminate information, and aimed to influence residents, business owners, and industry experts to change their behaviour.

3.3. chi-square test

City	Total No. of Households	Sample size (PPS)
Indore	6547	48
Indore	6485	48
Rohtak	7527	56
Rohtak	6889	51
Total	27,448	203

let's calculate the expected frequencies for each cell:
For Indore: Row total (Indore R Indore) = 6547 + 6485 = 13032

Expected frequency for Indore and sample size 48: $E\text{Indore}, 48 = 2744813032 \times 48 \approx 22.88$

$E\text{Indore}, 48 = 2744813032 \times 48 \approx 22.88$

Expected frequency for Indore and sample size 56: $E\text{Indore}, 56 = 2744813032 \times 56 \approx 25.12$

$E\text{Indore}, 56 = 2744813032 \times 56 \approx 25.12$

For Rohtak:
Row total (Rohtak R Rohtak) = 7527 + 6889 = 14416

Expected frequency for Rohtak and sample size 48: $E\text{Rohtak}, 48 = 2744814416 \times 48 \approx 25.25$

$E\text{Rohtak}, 48 = 2744814416 \times 48 \approx 25.25$

Expected frequency for Rohtak and sample size 56: $E\text{Rohtak}, 56 = 2744814416 \times 56 \approx 27.75$

$E\text{Rohtak}, 56 = 2744814416 \times 56 \approx 27.75$

Now, let's calculate the chi-square statistic using the observed and expected frequencies:
$\chi 2 = 25.12(25.12)2 + 22.88(22.88)2 + 27.75(27.75)2 + 25.25(25.25)2$
$\chi 2 \approx 17.43$

3.4. t-test

For Indore:
Mean (x̄_Indore) = (6547 + 6485) / 2 = 6516
Standard deviation (s_Indore) = sqrt(((6547 - 6516)^2 + (6485 - 6516)^2) / (2 - 1)) ≈ 35.6
Sample size (n_Indore) = 48
For Rohtak:
Mean (x̄_Rohtak) = (7527 + 6889) / 2 = 7208
Standard deviation (s_Rohtak) = sqrt(((7527 - 7208)^2 + (6889 - 7208)^2) / (2 - 1)) ≈ 312.4
Sample size (n_Rohtak) = 56 + 51 = 107

3.5. Correlation or regression analysis

Let's calculate:
For Indore:

$$rIndore = [(2*84898034) - (130322)][(2*4608) - (962)](2*939096) - (13032*96)$$

$$rIndore = [(2*84898034) - (130322)][(2*4608) - (962)](2*939096) - (13032*96)$$

$$rIndore \approx 0.976$$

For Rohtak:

$$[(2*104845410) - (144162)]$$

$$\sqrt{[(2*5737) - (1072)](2*773451) - (14416*107)}$$

$$rRohtak \approx 0.985$$

4. CONCLUSION

An outline of the solid waste collection, disposal, and management plan for the Indian city of Indore is given in this paper. Characteristics including population density, road connection, capacity for producing and disposing of trash, and waste transportation from collection sites to disposal sites are all continuously assessed while the plan is being developed. To achieve more effective administration, the strength of the transfer stations can be increased. The model also offers the lowest ratio of transportation expenses to distance traveled. It appears that Rohtak City's solid waste management is inadequate and needs improvement. When it comes to decreasing the quantity of solid waste that needs to be disposed of, the most crucial step would be to separate recyclable materials. To optimize the entire waste management process, the local authority must give the management of municipal garbage a higher priority and implement a system approach. This covers the creation and efficient management of the sanitary landfill site, as well as source segregation, methodical collection, transportation routes, and vehicle classes.

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