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Designing Storage, Collection and Transportation System of Municipal Waste

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Abstract. Since the main portion of the budgets of municipal solid waste management is spent on collection and transportation costs, any changes and purposeful planning through developing operational and technical system can cause to improve community health, and satisfaction of service recipients. In this paper, using management- economic software (WAGS) for municipal waste, the system of storage, collection, and transportation of municipal solid waste was designed for the Sarein city which is the tourism pole of Ardabil province in the North West of Iran. Based on the results of the software analysis, all requirements including manpower, facilities and equipment needed for system storage, collection and transportation were predicted for the Sarein tourist city. Designed system has been performed according to the approach in which recycling from the origin in two forms of wet and dry material containers and waste collecting machineries for dry and organic wastes. Utilizing (WAGS) software showed that through software required accurate information which includes 40 influencing factors on designing storage and collection of municipal waste, it is possible to provide an appropriate model for organizing and planning of storage, collection and transportation management of urban wastes.

Keywords: Waste management, Storage, Collection and transportation,Rrecycling from the origin, WAGS software.

1. Introduction

Waste production is a global issue and its importance is increasing day by day. This is a result of two main factors which are population growth and increase in consumption. In addition to the problems of rapid population growth, increase and variety of consumer goods and products, rising trend of consuming culture, increasing use of disposable materials and uncontrolled expansion of cities caused to produces millions of tons of wastes in cities (1). Sarein city which is the tourism pole of Ardabil province and has been located in the North West of Iran and with numerous hot springs is in foot of Sabalan Mountain, is not excluded from this issue and because of being a tourism attraction, has growing amount of urban waste. Establishment of a comprehensive solid waste management system is of significant factors on production control, frugality, material consumption and waste collection and disposal process, as well. (2). Nowadays, complications which occurred in the urban population, caused to create dramatic changes in quality and quantity of waste, in which these variations and complexities has been followed by making problems such as handling difficulties and also how to dispose of waste (3). Transportation problem and the future of collection systems always has been gripped human being and forced him to look for remedy against it (4).

Different methods have been presented by researchers to evaluate collection systems which one can consider the Arcobjects processing method and ratio estimation in which, each has its own characteristics.(5، 6 ،7)

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In 2004, a research was conducted by William to evaluate the solid waste management system of New York City which was done using field data and ratio estimation. In 2008, other investigations were done in Norway, in this regard by Zeiler, Larman and Huang which they had used the Arc objects processing research method in VBA programming environment.

Another method in designing storage, collection and transportation system of municipal solid waste is using data processing WAGS programming environment (8). Using the WAGS software to evaluation solid waste transportation system in 10th district of Tehran, Researchers came to the conclusion that, solid waste transportation system in this distinct has fundamental defections and available equipments are not perfect for status quo and future of the municipal solid waste management system. Therefore the facilities needed to fix existing problems and future development plans and estimates were presented. Aiming at designing storage, collection and transportation system of municipal solid waste and with respect to the features of WAGS software, this approach has been employed in our research.

2. Materials and Methods

2.1. Study Area

Sarein tourist city is in 04/48 Longitude and 09/38 latitude of geographical coordinates and with an area of over 1.28 million square meters, has been located in 28 kilometers of West of Ardebil city and northwestern of Iran. The average height of the city is1650 meters above sea level. Most part of the city in a bowl-like valley which has been generated from gentle slopes of foothills of Sabalan Mountain.

According to the latest survey which has been conducted in 2011, Sarein tourist city has population of 6121 resident. In addition to its urban population and due to being a tourism attraction, according to Cultural Heritage and Tourism Organization of Ardebil province, this city gives services annually to 5200000 tourists across the country and from around the world. Based on available statistics, the highest number of tourist daily, has been reported to be about 85,000 people during the peak time in summer. The amount of waste generated per capita in the city is 0/930 kg per day. In total, more than 6453 tons of waste is produced annually in this city. Currently, there isn't any system of recycling and separation from the origin being done in this city and all stages of storage, collection and transport up to the location of waste landfill is being made semi-mechanized. During the past three years, taking advantage of automated collection system as one of the metropolitan strategies has been concerned with Sarein municipality. The main purpose of this system is efficient and sanitary collection of solid waste as well as meeting the needs of citizens.

Since establishment of this automated system has not been done according to scientific and technical studies, it has some deficiencies and this research has been conducted to fix such problems.

2.2. Data Analysis for Designing Storage, Collection System of Municipal Waste Using WAGS Software

WAGS software was designed in the 1990s by the Human Settlements Centre (UN-Habitat) of United Nations for transportation part of the required six elements of the solid waste management. This software has the predictive capabilities of required facilities for municipal waste transportation system during prospective 14 years and if you need to estimate and design, storage and collection system for more than 14 years, the output of the first 14 years will be used as the required input data for the next 14 years. Statistics and data required to software analysis include main 40 questions and 16 defaults.

Information required for waste storage, transportation and collection system of Sarein city were entered to the software as the following:

1. Population: 91 121 persons(resident population + population entered in a day).
2. Population growth rate: 2/02 percent.
3. Waste generation rate: 0/930 kg per person per day.
4. Annual growth rate of waste generation: 5/2 percent.
5. Density of waste: 360 kg per cubic meter.
6. Percentage change in density of waste due to a change in social culture: 75% per year.
7. The acidity of the waste: 1 (number one for the acid and zero for the neutral).
8. Waste roughness: 1 (number one for rough waste, and zero for soft waste).

9. Position of study city to the coastal areas: 0 (away from coastal regions).
10. Waste collection: 2
11. Distance from locations of waste collection to waste disposal / landfill: 6 km
12. The maximum allowed load weight to be transported through the country roads: 10000 kg.
13. Width of streets and alleys that waste should be collected from: 8 m.
14. Road factors: 80%.
15. Number of working weeks: 52 weeks.
16. Number of working days: 7.
17. Number of shift / shifts: 1.
18. Number of working hours per shift / shift: 10.
19. Efficiency rate: 75%.
20. Labor cost: 318 $.
21. Labor Shadow Factor: 0 /5 percent.
22. Drivers Cost: 318 $.
23. Driver shadow factor: 0 /5 percent.
24. Management overhead: 15%.
25. The currency exchange rate: 0/8 $.
26. Exchange rate shadow factor 1.
27. Cost of fuel: 1.6 $.
28. Fuel Shadow factor: 1/5.
29. Tax on car imports: 10%.
30. Tax on Sale: 10%.
31. Opportunity of investment costs: 20%.
32. Taxes on imports of auto spare parts: 10%.
33. Maintenance periods of machineries: 0 percent.
34. Distance to transfer station: 6 km.
35. Time intervals between daily discharges: 1.
36. Required excess capacity: 30%.
37. Premium of large vehicles: 595$.
38. Premium of small vehicles: 277$.
39. Road traffic tax on large vehicle : 0.
40. Road traffic tax on small vehicle : 0.

Additionally, the default 16 items that of the mechanized waste collection machinery specifications of Sarein city was entered to the software as the following:

1. Machine's
2. weigh when it is empty: 4,500 kg.Alpha
3. The (normal) loading weight of the vehicle: 2500 kg.
4. The (normal) loading weight of the vehicle: 3200 kg.
5. Loading volume: 5 cubic meters.
6. Average speeds good roads: 70 km per hour.
7. Average speed on bad roads: 25 km per hour.
8. Fuel consumption of vehicles: 9 liters per hour.
9. Number of employees (except for the driver) for each vehicle: 2.
10. Width of the vehicle: 1/6 m.
11. Required time to fill a vehicle: 100 minutes.
12. Required time to discharge the waste in the transfer station (from arrival to discharge): 15 minutes
13. Time that waste transportation vehicle is off for minor repairs such as flat tire, etc: 5%.
14. Repair and maintenance costs of waste transportation vehicles over a year: 15%.
15. The economic life of waste collection vehicles: 10 years.
16. The price of the vehicle: 71428 $.
17. Fuel price per liter of gas oil (gasoil): 23 cents.

3. Results and Discussing

Results of the software analysis for designing storage, collection and transportation system of municipal waste of Sarein city were obtained in six sections as the following:

3.1. General Information

- Waste collection time as well as Sweeping time of waste transportation vehicle to waste disposal sites were estimated to be128/99 minutes.
- Waste Compact volume was 5 cubic meters in waste transportation vehicle.
- Maximum weight of waste was 2000 kilograms in waste transportation vehicle.
- Performance of waste transportation vehicle in waste collection and transport to landfill were determined to be 95%.

- The economic life of waste transportation vehicle under conditions of Sarein city was determined to be7/6 years.

3.2. Predicting the Amount of Produced Waste

Sarein population in 2011 along with the tourist population during peak tourist presence in the region were 91 121 people. The amount of waste generated per capita in the city is 0/930 kg per day. Also the growth rate of waste generation in the region was about 2/5 % in 2011 . Due to the high population growth rate on the one hand and increasing of waste generation per capita and raising tourist population on the other hand, the amount of produced waste in 2025 will be of 87 826 tons.

Diagrams 1 to 4 show population growths, increasing of waste production per capita, the annual waste generation, and waste density changes from 2011 to 2025 in Sarein city, respectively.

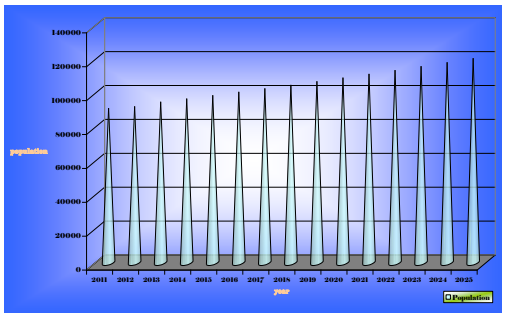


Fig. 1: Population growth trend in Sarein

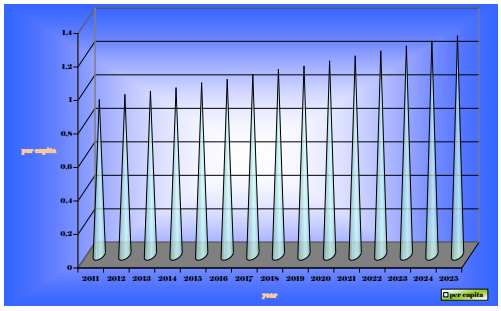
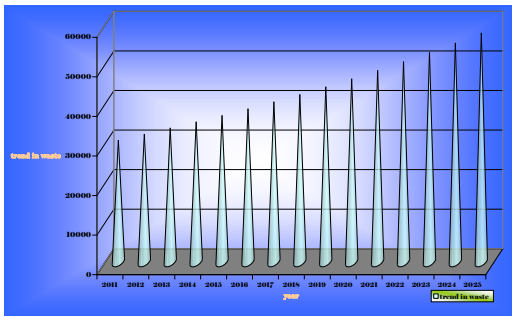
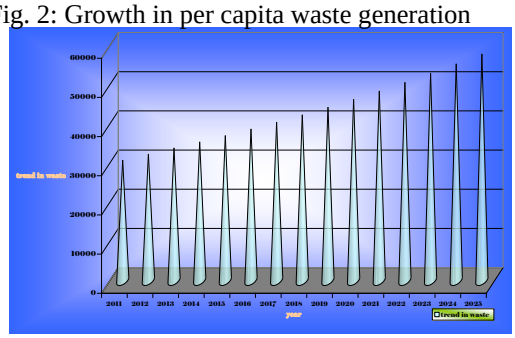


Fig. 2: Growth in per capita waste generation





3.3. Predicting the Required Machinery

Automated machines are utilized in Sarein city for waste collection and transportation to the transfer station. Therefore machinery requirements have been formed according to waste transportation vehicles as well as current trend. WAGS program show that to waste transportation vehicles is needed to waste collection in 2011.

This number will be reduced to 14 in 2012 and again in 2013 will be increased to 15 and finally in 2025, if this trend continues then the necessary number of vehicles will increase to 24.Diagram 5 indicates the annual status of waste transportation machineries.

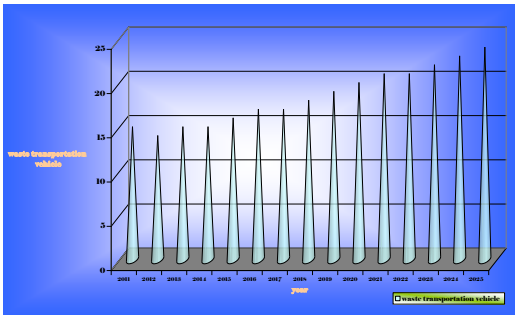


Fig. 5: The trend of purchasing waste transportation vehicle by Sarein municipality

3.4. Anticipating Capital Requirements for the Purchase of Machineries

In order to provide the needed machineries in the years 2011 to 2025, capital prediction has been made. In the base year (2011), 706350 $ has been paid in total which includes 15 waste collection vehicles from the previous years to 2011. In 2025, 1832858 $ budget is required to buy waste collection vehicles. Diagram 6 shows investment trend in the years 2011 to 2025.

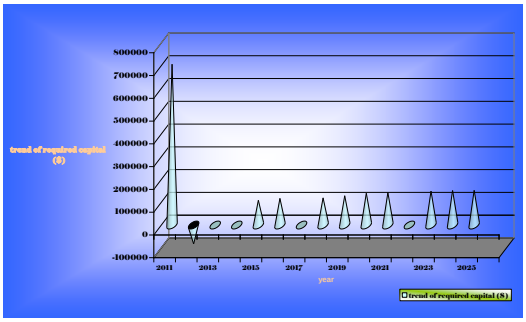


Fig. 6: The trend of required capital accumulation by Sarein municipal for the purchase of waste transportation vehicles

3.5. Anticipating Capital Requirements for Supplying Manpower

Diagram 7 shows increased trend in driver‘s, labor’s, and management costs .And diagram 8 represents the trend in number of required drivers and labors in the system during years 2011 to 2025.

As mentioned in diagram 7, manpower supply costs will increase from 342858$ in 2011 to 967538$ in the year 2025.

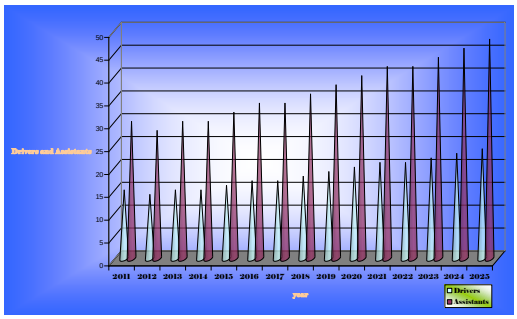


Fig. 7 represents the trend in number of required drivers and labors in the mechanized system during years 2011 to 2025.

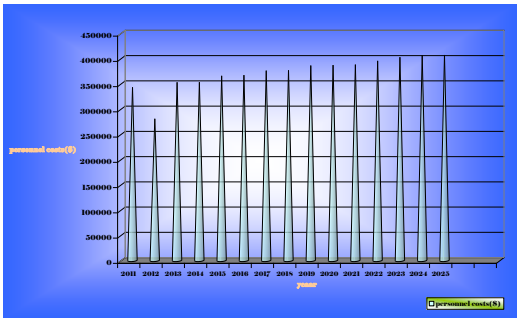


Fig. 8: The trend of investment needed for personnel costs by Sarein municipality.

3.6. Anticipating Costs for Fuel and Maintenance

Diagram 9 shows the costs of fuel and maintenance, in the area during years 2011 to 2025.

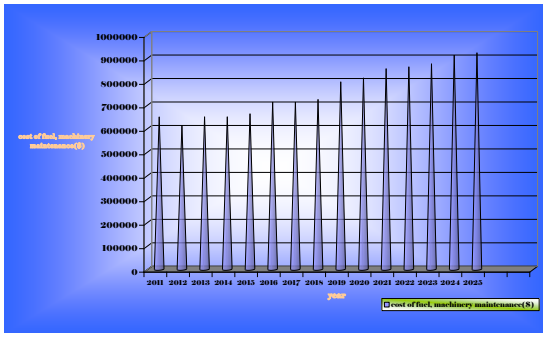


Fig. 9: The trend in cost of fuel, machinery maintenance in study area

4. Conclusion

This study was took place to estimate the resources required to waste collection and transportation systems using software WAGS in Sarein tourist city. Survey results indicated the use of traditional and none

scientific methods in waste management of Sarein city. Therefore, attention and applying related sciences and techniques to optimize these systems which are directly related to the lives of citizens is a necessity and can cause to economizing costs of waste management in this city.

The result of this research in optimization of waste collection system in Sarein city was led to estimation of mechanized system's required resources to collect and transport waste in this city. Based on this, collection and transportation of solid waste in Sarein city, Sarein municipality should purchase collecting machineries worth 183285$ until 2025 which is equal to 37% of its needed budgets during these years. Personnel costs during the next 15 years was estimated to be 5585614$ that includes 34% of the total cost of collecting and transporting solid waste. Costs associated with repairs and maintenance of collecting machineries was estimated to be 10499000$ by the end of 2025, that this amount is equal to 24 % of the total budget of Sarein city over the next 15 years. Fuel costs over the next 15 years is 915658$, which is 4 % of the total anticipated budget. In addition, about 1 % equivalent to 660715$ was allocated for other expenses such as rises in fuel prices, wages and also in the costs associated with repairs.

The results of this research can be used to modify available deficiencies in municipality and planning to provide new machineries, equipments and trained personnel in municipal solid waste management systems in accordance with city growth and urbanization in the future. The survey outcomes indicate WAGS software capabilities on good estimation of collection and transportation system's requirements is municipal waste.

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