Route Optimization for Effective Municipal Solid Waste Collection System in Selected Wards of Mysuru City

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Abstract: Municipal solid waste management is an obligatory function of the Urban Local Bodies (ULB) in India. With growing population and increasing waste generation, solid waste management has become a significant environmental issue. Waste collection becomes more complex in developing countries in terms of logistic, fuel and labor cost and air Pollutant emission. During this study, solid waste collection routes optimization using Geographical Information System (Arc GIS) was investigated. So as to match the whole travel distance between these existing routes and optimal routes, several routes were created during a random day. In total, there are 7 waste collection route which covers the ward 61, 62 and 63 of Mysuru city. The quantity of routes is adore the amount of vehicles to serve the world. Here we consider two collection vehicle i.e. Auto tipper and Tata Ace for waste collection in ward 61, 62 and 63 of Mysuru city. The proposed system demonstrated promising results, with a saving efficiency of Auto tipper and Tata Ace has 42.34 try to 33.33% respectively. And also there's decreases in collection costs, fuel consumption and CO2 emissions.

Keywords*:* MSWM, ArcGIS, Optimized waste collection route.

Introduction

Municipal solid waste (MSW) also termed as a 'garbage' or 'trash' is an inevitable by-product of act. It's generated by many sources (household, hospitals, shops, hotels, etc.) and are of mainly two types organic (food, fruit, plant leafs, etc.) and inorganic (paper, plastic, glass, dust, etc.) The quantity of sources of MSW are increasing because of rise in urbanization, and is resulting in the assembly of an enormous quantities of solid wastes which successively encompasses a high negative impact on collection cost and environment (Rathore & Sarmah, 2019). Municipal solid waste (MSW) transportation consists of multidisciplinary activities which include forecasting, generation, storage and collection, transportation, treatment, and waste disposal. Of of these activities, transportation alone account for 50–70 % you look after the whole cost of the system (Rada et al., 2013; Tavares et al., 2009). This collection cost is increasing thanks to growth, the increment in MSW generation rate, unavailability of lands nearby for landfills, and high collection time. (S P Sarmah et.al, (2019)).

Mysuru is one among the historic city of south India and ex-capital of Mysuru state. Solid waste management in Mysuru city is that the obligatory function of Mysuru City Corporation (MCC). MCC comprises of 65 wards, which consists of 2,06,370 households. Solid waste management of a number of the wards, 4 markets and main roads are privatized because of the shortage of workers. In Mysuru demarcation about 450 heaps of solid waste is generating daily. 22 tractor trailers, 1 tipper, 2 dumper placers and 5 Lorries are getting used by MCC for the transportation of waste and 24 Lorries are employed by private contractors. Mysuru city has a centralized compost plant at Vishveshwara Nagar which is of 200 Tpd capacity. (Lokeshwari.M et.al,(2014))

Geographic Information Systems (GIS) are one of the most sophisticated modern technologies to capture, store, manipulate, analyze and display spatial data. These data are usually organized into thematic layers in the form of digital maps. The combined use of GIS with advanced related technologies (e.g., Global Positioning System – GPS and Remote Sensing - RS) assists in the recording of spatial data and the direct use of these data for analysis and cartographic representation. (Christos Chalkias et.al (2010))
ArcGIS is a geographic information system (GIS) application developed and maintained by the American company Esri.
ArcGIS Network Analyst helps to dynamically model realistic network conditions and solve vehicle routing problems in a transportation system that include turn restrictions, speed limits, height restrictions, and traffic conditions at different times of the day.(http://desktop.arc.gis.com/en/) ArcGIS help 10.1.

Methodology

Data collection:

In this study we analyze the current system and propose a brand new optimal routes. Study area considered during this study, is that the 3 wards of Mysuru city, Ward 61 (Vidyaranya puram), Ward 62 (Vishweshwara nagar), Ward 63 (JP Nagar).fig shows the study area. This Wards uses 7 collection vehicle i.e. 4 primary collection vehicle and 3 secondary collection vehicle to gather the waste within the study area.

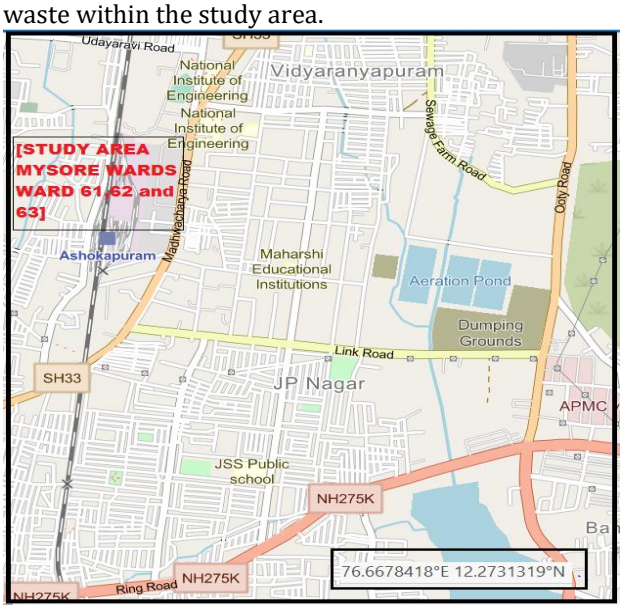

Fig 1: study area (Mysuru city wards 61, 62 and 63)

The road network was the foremost essential data required for the study. The urban road network was provided by the Google earth. The road network of the wards of Mysuru city was generated with Global Positioning System (GPS) and satellite imagery. We surveyed solid waste collection points with a high-resolution GPS during a vehicle. The latitude and longitude of every collection point was recorded from inside a survey vehicle.

Methodology of GIS:

The waste collection optimization model was developed with the employment of ArcGIS Network Analyst (NA) GIS software. The subsequent data were obtained and processed in suitable forms (vectors, tables, and raster): delimitation of the study area; detailed existing waste collection route of the gathering vehicle; population distribution and density; satellite image (Google Earth) and road network.

Once our database is established, the optimization model is performed with the utilization of the Network Analyst (NA) tool on ArcGIS. This work was meted out considering the particular scheme of collection and transportation still as other proposed scenarios.

In the present work, present solid waste management system was studied and first collection vehicle and secondary collection vehicles are considered as bins for waste collection and transportation of waste. At present there's no entire topographic point Bins employed in the town. Study proposed the optimal route for both primary collection vehicle and secondary collection vehicle which covers 100% collection of waste generated within the area and optimal routes were identified using Arc GIS.

Result & Discussion

Existing waste collection routes:

In order to check the whole travel distance between these existing routes and optimal routes, several routes were created during a random day. In total, there are 7 waste collection route which covers the ward 61, 62 and 63 of Mysuru city. The amount of routes is admire the quantity of vehicles to serve the realm. Here we consider two collection vehicle i.e. Auto tipper and Tata Ace for waste collection in ward 61, 62 and 63 of Mysuru city. Existing solid waste collection routes were obtained by MCC (Mysuru City Corporation). The present routes from each collection point to the prevailing landfill sites are shown in Fig.2 Auto tipper and Fig 3 Tata ace.

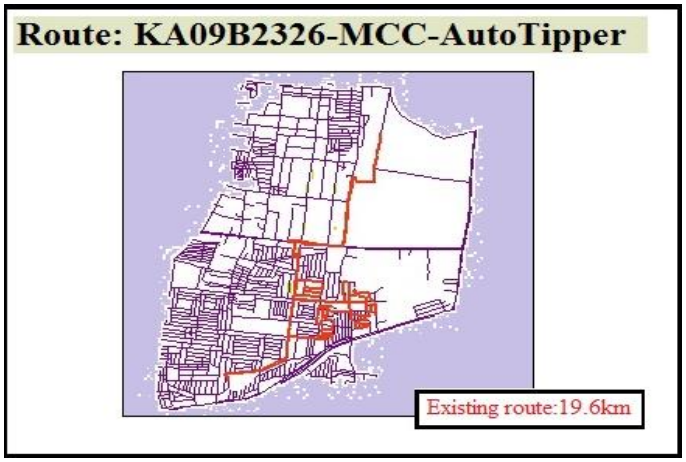

Fig 2: Existing route of MCC Auto Tipper

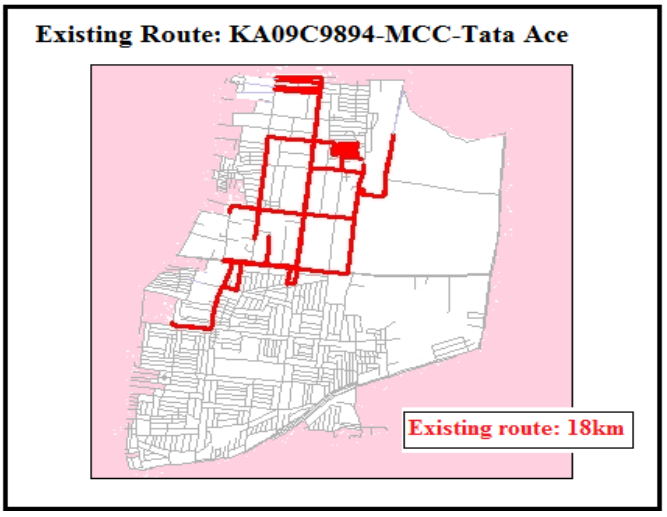

Fig 3: Existing route of MCC Tata Ace

The original collection route distance for auto tipper and Tata Ace were 19.6km and 18km, respectively.

Optimized Waste Collection Routes:

Generating Optimal Waste collection Route:

Collection routes were worked out by using the VRP tool in the Network Analyst® feature of ArcGIS with the planned infrastructure (urban areas, road network, collection points, and landfill sites) to find the shortest and quickest paths by minimizing total travel distance. However, the road condition and weather impact on driving were not part of this study. We generated the shortest route or optimal route from each collection point to the nearest landfill site as shown in Fig 4 and Fig 5. Optimized route auto tipper and optimizes route Tata Ace. The obtained optimal waste collection route distance for auto tipper and Tata Ace were 11.3km and 12km, respectively.

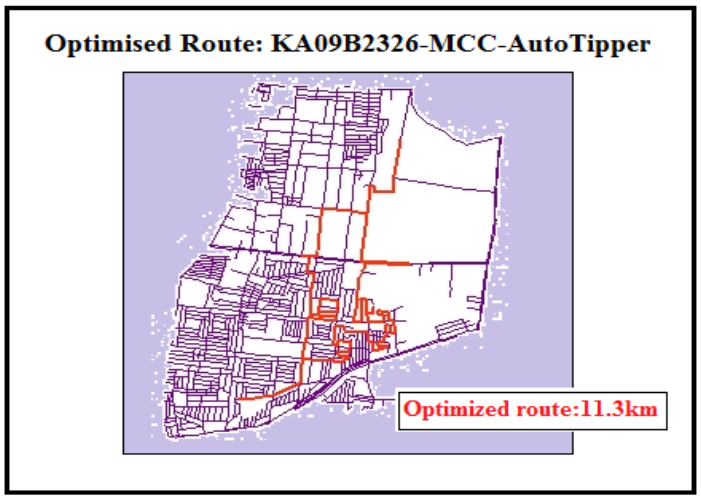

Fig 4: Optimized route of MCC Auto Tipper

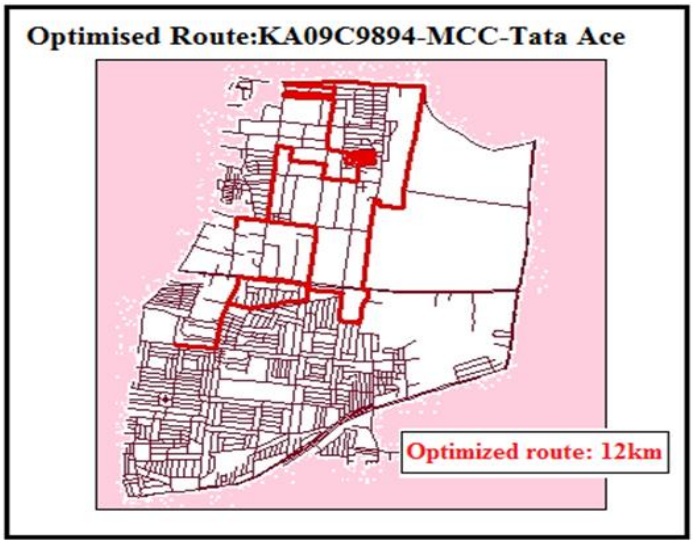

Fig 5: Optimized route of MCC Tata Ace

Comparison of the Existing waste collection route and the Optimized route:

The existing and optimal waste collection route distance for auto tipper and Tata Ace are shown in Table1. The detailed calculations for fuel consumption rate, carbon emission, percentage change in the existing and optimized routes by distance for the wards 61, 62 and 63 of Mysuru city are shown in Table. Mostly, route optimization studies focus on calculating the shortest distance or minimum driving times for the collection and transportation of waste. Our research has shown that using advanced routing with appropriate parameters and procedures can return significant cost savings, and this can be attained either by decreasing mileage/distance driven. Therefore, actual savings from existing and the proposed routes are shown in Table 1.

Table 1: Comparison of the Existing route and the Optimized route.

Collection vehicle	Auto Tipper		Tata Ace	
	Existing route	Optimized route	Existing route	Optimized route
Route distance In km	19.6	11.3	18	12
Fuel consumption In L	0.7841	0.4522	0.8571	0.5714
Fuel consumption Cost in Rs	73.10	42.15	79.90	53.27
Carbon emission in kg	2.0543	1.1847	2.2456	1.4970
Difference in km	8.3km		6km	
Saving efficiency in %	42.34%		33.33%	

Result indicates that the travel distance of collection vehicle of auto tipper and tata ace has reduced from 19.6 Km and 18 Km to 11.3 Km and 12km, respectively. This research has shown that using advanced routing and procedures can return the significance cost savings, this can achieved by decreasing overall travel distance. The impact of reducing travel distance can also reduce the carbon emission. The saving efficiency of auto tipper and Tata ace are 42.34 % and 33.33% respectively.

CONCLUSIONS

• Network analysis performed during this study is for locating the optimal route within the collection of waste from various waste collection locations within the city. It reduces the travel distance and facilitates more efficient

collection of waste from disposing areas/waste collection locations.

• The optimized route reduced the whole driving distance, which successively decreased the fuel consumption. Consequently, the collection(gathering) costs and pollutant emissions were diminished.

• The proposed system demonstrated promising results, with a saving efficiency of Auto tipper and Tata Ace has 42.34 attempt to 33.33% respectively. And also there's decreases in collection costs, fuel consumption and CO2 emissions.

• Our study will be a decent decision support system/tool for waste transport, fuel consumption, load balancing across vehicles, and generation of work(labor) schedules for both employees and vehicles. Furthermore, this study will be used as a benchmarking tool by the municipal administration for efficient management of the daily operations for SWM.

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