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Route Optimization of Vehicle Collecting Municipal Solid Waste: A Review

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ABSTRACT
Solid waste management is a crucial challenge faced by developing economies due to rapid urbanization and population growth. Inadequate management of solid waste can lead to severe negative consequences on society and the environment. Solid waste management processes include generation, collection, transportation, treatment, value recovery, and disposal. Inefficient collection and transportation account for a significant portion of the total cost of solid waste management, which can lead to environmental pollution. Therefore, achieving sustainable solid waste management in developing economies requires cost reduction in collection and transportation. Optimizing collection and transportation through system analysis and operation can lead to the efficient and effective solid waste collection while ensuring cost reduction and environmental conservation. This review paper highlights solid waste management challenges in developing economies, emphasizing the importance of efficient collection and transportation to achieve sustainable solid waste management. The review provides insights into the optimization of collection and transportation processes through system analysis and operation, highlighting the benefits of cost reduction and environmental conservation.
Keywords: *Waste Generation, ArcGIS model, Route optimization, Solid waste management*

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I. INTRODUCTION

Solid waste refers to unwanted material generated from manufacturing processes or community and household activities, commonly referred to as rubbish, trash, junk, or garbage (Akhtar et al 2015). Inadequate solid waste management can negatively affect society and the environment (Basavaraj and Prakash et al 2011). Developing an effective and environmentally sustainable solid waste management system is a significant challenge for developing economies, exacerbated by the high waste generation rate resulting from rapid urbanization and population growth, inadequate financing, poor waste disposal attitudes, and lack of political will (Amir Hossein and Khalil et al 2013).

Solid waste management includes the processes of generation, collection, transportation, treatment, value recovery, and disposal. Inefficient collection and transportation account for a significant portion (60%-80%) of the total cost of solid waste management (Tavares et al 2009), (Salah et al 2014). Ineffective management increases operational costs and can result in environmental pollution. Achieving sustainable solid waste management in developing economies requires cost reduction in collection and transportation. Optimizing collection and transportation through system analysis and operation can lead to the efficient and effective solid waste collection while ensuring cost reduction and environmental conservation.

1.1 Need for Route Optimization

Efficient collection and transportation are critical components of a sustainable solid waste management system in developing economies. Inefficient collection and transportation account for a significant portion of the total cost of solid waste management, leading to increased operational costs and environmental pollution. Therefore, optimizing the collection and transportation processes through route optimization is essential to achieve cost reduction and environmental conservation. System analysis and operation can help to identify the most efficient routes for solid waste collection and transportation, taking into account factors such as waste generation rate, population density, road conditions, and collection frequency. Route optimization can lead to reduced travel time, fuel consumption, and vehicle wear and tear, resulting in cost savings and reduced greenhouse gas emissions.

Thus, the need for route optimization in solid waste management is crucial for achieving sustainable development in developing economies.

1.2 Software used for Route Optimization

i. Arc Logistics: Arc Logistics is a route optimization software that uses GIS (Geographic Information System) technology to optimize routing and scheduling. It can handle complex routing scenarios and provides real-time updates for changes in traffic or weather conditions.
ii. OptimoRoute: OptimoRoute is a cloud-based route planning and optimization software that allows users to create and optimize delivery routes based on distance, time, and constraints.
iii. Route4Me: Route4Me is a route optimization software that uses a proprietary algorithm to calculate the most efficient route for deliveries or pickups. It can also account for factors such as traffic and weather conditions.
iv. MyRouteOnline: MyRoute Online is a route planning software that allows users to create and optimize multiple stop routes for deliveries, pickups, or service appointments.
v. Circuit: Circuit is a mobile app for iOS and Android that provides route optimization for field service and delivery teams. It integrates with popular mapping apps such as Google Maps and Waze.
vi. RoadWarrior: RoadWarrior is a route optimization app that allows users to plan and optimize their delivery or service routes, and provides turn-by-turn directions and real-time traffic updates.

II. LITERATURE REVIEW

1. Alexander P. et al (2003) Conducted a study for Texas City, in this study, they are focusing on route reduction of Solid Waste collection vehicles with the help of GIS technology. The collection is focusing on three major areas such as commercial, residential, and industrial. Depending upon the area, a driver decides how many times to visit them in a week. Based on a customer's address, a GIS would provide spatial information such as the customer's address in a coordinate system and the geometry of the client's pickup site, usually a point, line, and polygon. In 2003 waste management established waste routes all over the Nation. By the end of the year, management found 984 optimized routes which saves approximately $18 million. The most effective improvements were noticed in the Oregon market area, which optimized 46 routes. While the goal was of reducing 12.

2. Khedkar S. et al (2006) carried out a study in Pune. She working on ArcGIS to optimize the route of solid waste collection vehicles. They develop spatial data sets for all 15 wards. After that route optimization process was carried out. The study considers some essential restrictions too. Such as no U-turns, and trucks should follow Tree shape routes. 15ward Area was considered for the study. After implementing ArcGIS optimized route, a 9.93% route deduction was noticed. And the time taken by the vehicle for both paths optimized route path and the non-optimized route path was calculated as well.

3. Gonullulu M.T. et al (2006) conduct this study in the city of Turkey with the aim of route optimization for a reduction in financial cost and time. They use a video camera to record solid waste collection vehicle movements. To route optimization process and with the help of GPS receiver for collection of data. After that, those data were analyzed in ArcGIS. After performing route optimization by ArcGIS deduction in route was 4-59% distance and 14-65% for time. And 24% benefit was observed in the total cost for the route optimization process on the street stationary container collection system.

4. Chalkias C. et al (2006) study was carried out in Greece. The purpose of this study is the reduced the cost of solid waste collection vehicles so people can afford the waste charges. By using ArcGIS technology to enhance the efficiency of the collection of waste and its transportation. After implementing the proposed route, Results indicate that the optimum route distance considerably enhances the efficiency in terms of collection time and travel distance. Before optimization, the traveling distance for the solid waste collection vehicle was 11.0KM which is reduced to 9.8 km After optimization. This is considerably 12.5% low comparatively existing route. The total travel time for municipal solid waste collection vehicles was the optimal route is 4 hours and 19 minutes instead of 5 hours and 11 minutes of the existing route.

5. Ericsson L. et al (2006) carried out a study in Sweden. The analysis was established on a large database of present traffic driving patterns which is straightly connected to the street network in the city of Sweden. An entire study was carried out on the base of 15437 cases, considering 22 streets of the city network at their highest peak hours. By ArcGIS whole city travel route network was established and upon this concerning the shortest time and shortest distance. It was demonstrated that for 46% of trips in a city, the driver's selected route was not the most fuel-efficient. These existing routes could save, on average, 8.2% fuel with the help of an optimized route navigation system.

6. Omar A. et al (2008) conducted a Study carried out in 39 cities in Turkey and performed route optimization to decrease the emission. They make a model to optimize the route of municipal waste collection vehicles to reduce emissions. With the use of GIS, an efficient route for collection vehicles was identified. During the study, they use a digital camera, and visual records were made in case of route variations. Distances covered

during the trip were cross-checked again with the help of a digital map and vehicle tachometer. With the use of an optimized route, they save distance and time by 26.7% and 44.3% respectively.

7. Gilberto T. et al (2008) conducted a study in Portugal. He studied the total cost of collection and transportation cost of solid waste management and how to make cost benefits with the help of a route optimization network for waste collection and transportation. They worked on GIS modeling for waste collection and optimization of the route. After using ArcGIS route optimization, they found 52% in fuel savings. They are as working both locally and globally. Significantly saving to 9% and 52% saving in fuel respectively.

8. Semiao V. et al (2008) conducted a study in Cabo Verde. He performs cost reduction analysis because a collection of municipal solid waste accounts for 70 % of the waste management budget. This study they divided into two parts first one is considered a Praia city and another one is known as Santiago Island. In the case of the former one, considerable differences were observed with the help of ArcGIS optimized route was 29% lesser than the regular one and 16% for the lowest fuel consumption Studied carried out on Santiago Island to reduce the cost of fuel with the help of route optimization of solid waste management vehicle. By implementing this short route technic, they can save 12% of the cost. GIS recommendation route was able to cut the route by 1.8%.

9. Lasaridi K. et al (2009) conducted a study in Athens. She studied methodology for the optimization of the route for waste collection and transport with the help of GIS technology. The model was developed in ArcGIS to improve waste collection in the municipality of Nikea, Athens. For this large amount of data for the period of 1998-2007 was collected from the municipality. Data includes existing population density, number, waste generation rate for mixed waste, type, and positions of waste bins, the existing routing system of the collection vehicles, truck loading capacities, and vehicle characteristics. Comparing two scenarios with each other namely A and B. In former scheme A collection vehicle routing optimization and in B reallocation of bins and routing optimization. Results indicate that both cases prove effectively save comparatively existing situations in terms of collection time. 3.0% and 17.0% for cases A and B respectively and travel route 5.5% in case of A and 12.5% in case of B. Reduction in Time and distance relate to emissions and fuel consumption savings.

10. Ogwuleka S. et al (2009) conducted a study in Nigeria. He studied that the collection of solid waste in big cities is a challenging task. He introduced solid waste collection in this study. The study mainly aims at the reduction of the overall cost, which generally depends on the route distance traveled by the collection vehicle. The study was also compared with the current route for cost, time, and distance traveled by collection vehicle. The adoption of the proposed optimized route network technique resulted in a deduction of the number of existing vehicle routes, savings in collection cost of refuse waste of 22.86%, and a reduction in vehicle distance traveled per day computed as 16.31%. The result demonstrated excellent performance of the proposed method, which is prove very beneficial in a futuristic approach.

11. Prakash S.M. et al (2011) conducted a study in Bangalore. He researched a current scenario of transportation of solid waste along with the various secondary routes of selected wards of Bangalore. With the help of GIS, importing the data into GIS best optimization route that can be found. The process of studying spatial data was collected, then identifying the collection point including segregation, and finally optimization of routes, minimum time, and distance. GIS technology proves effective in optimizing the waste transport routes to achieve reducing time and distance eventually resulting in a most economic transport model. Results show that 12.95 % reduction in distance and a 12.92% saving in operational cost. Reduction in travel time would directly lead to a reduction in environmental hazards.

12. Bhambulkar A.V. et al (2011) conducted a study in Nagpur. analyzed the ArcGIS Network to identify the best route for municipal waste collection vehicles. To Network analysis, they relocated the loading spots. Due to a lack of space or prohibitive obstacles, some wastes are unattended. They used Network analysis to calculate interrelationships between dynamic factors. Examples like blockage of the road due to falling trees or car accidents such case study of the route and give an optimized solution. For this, they use the ArcGIS9 version. Laxmi Nagar Are was in practice for this particular like 28950 per month. After Network analysis, this cost was reduced by 14% every Month.

13. Zsigraiova Z. et al (2012) conducted a study in Portugal. She identified a new methodology for the mitigation of the operation costs and pollutants which is emitted during the collection of waste and transportation. Their new methodology consists of combining vehicle route optimization with that waste collection schedule. They used historical data to get more accuracy which is more realistic compared to the Assumption of data. With their new methodology, they successfully reduce 49% and 62% of the total time they spent while optimizing with the shortest distance and time, respectively, and about cost 45% and 57% with the same optimizations. Minimization in pollutant emissions is also noticeable reductions lied between 27% to 30%. optimizing the shortest distance and lay in 43% to 50%. And fuel consumption reduction is 28% and 43% for distance and time optimization respectively.

14. Khalil N. et al (2013) conducted a study in Malaysia. He studied that waste collection is a major problem in developing countries in terms of fuel and labor costs and air pollutant emissions. The problem can be solved with the help of Geographical Information System route optimization. Firstly, five routes were selected in various areas of the city for study and the current routes were optimized to reduce the length of the routes and

consequently, the time taken to complete the collection. Results show that length minimization in the routes is successful up to 22%.

15. Malakahmad A. et al (2014) conducted a study in Ipoh City. He studied that, proper route optimization which helps to improve the recycling of generated solid waste, and collects information related to solid waste collection and transportation in Ipoh and advice on the best route optimization which helps to improve the recycling of generated solid waste. They studied 22 zones of Ipoh City. They identified with conventional practice route of collection to Disposal are took 5hours. Therefore, they provide a new optimized route with the help of a geographic information system. GIS also helps in providing specified time, crew, and vehicles for the collection of recyclables. New identified route proves the best route network. collection schedule and recycling facilities should be produced to further improve the existing system.

16. Velumani A. et al (2014) conducted a study in Coimbatore and develop a proper storage and collection plan based on ArcGIS in the ward of the Singanalluar, Coimbatore. The study was carried out for any randomly selected ward. With the help of the software route optimization was performed. As a result, optimized solid waste collection route distance is reduced to 46%, and with distance reduction, vehicle running and maintenance expenditure is also decreased to 86.7%. The total Annual expenditure of Vehicle Running and Maintenance cost is 3,60,000 which is 1,64,980 rupees After route optimization. This proposed model is proving efficient for the municipalities for the management of Municipal Solid Waste.

17. Salah A. et al (2014) conducted a study in Deir El Balah. He performed Solid waste collection routing with the help of Esri's ArcGIS software. He found out in his study in the city of Deir El-Balah that 74% of the municipal budget was spent on collection only. This research considered the optimization of the route in the city for identifying the shortest route. The study reduced the total route distance for the collection vehicles. Results demonstrate that optimization of the collection network system by reducing the total distance by 23.47% leads to saving around US$1140 and US$13680 monthly and annually respectively. It is recommended that the Optimization route by ArcGIS study can be implemented in other municipalities as well thus significantly cost can be reduced monthly and annually.

18. Krishna A.P. et al (2015) conducted a study in Kolkata. He studied Waste haul from storage is transported for disposal by Kolkata Municipal Corporation. They face a challenge in presenting an acceptable, realistic solution optimizing the waste vehicle routes, which helps to cut down on the transportation cost and simultaneously increase overall efficiency. With the use of ArcGIS, they identified multiple paths and select the best one. Since the network analyst come into the Vehicle Routing Problem it easily solves problem such as solid waste collection and transportation process more accurately and convincingly. Results indicate that improves workforce management and increases the operational efficiency of KMC.

19. Sanjeevi V. et al (2015) conducted a study in Chennai. She studied that Most of the municipal corporation fund was spent on solid waste collection only. Hence, to reduce the cost of collections, improve the Solid waste collection route Network. Geographical information systems are been used to optimize the solid waste collection vehicle route. The task was performed for 13wards to one transfer station with the help of ArcGIS. After optimization take place, the route was reduced by 9.93% for 13ward taken under study.

20. Zaveri P. et al (2016) conducted a study in Surat. She studied that Surat City is divided into various zones they are as following North, East, West, South, South-East, Central, and Southwest. Among from those south provinces were further divided into 10 wards. Each ward has 12 collection points. They use ArcGIS to produce optimization routes for the Bhestan ward and Vadod-unn ward. Before the optimization of the route total travel distance for the Bhestan ward is 27Km and the total travel distance for the Vadod-unn ward is 41.4KM. After optimization, the total distance for both routes is about 23.2 km and 28.4KM respectively. The total deduction distance for both wards is 3.8 km and 13 km respectively. As Route length decreased time duration and fuel consumption also decreased by GIS-based Route Optimization.

21. Pasicha C. et al (2018) conducted a study on Si Chang Island. He studied road networks extensively and implement a network analyst extension, which was beneficial in the area of optimization of Municipal solid waste collection and transport. A couple of routes were indicated for Municipal solid waste collection. In two trips, about 10 tons of solid waste per day was collected by Two vehicles. The method in this paper included the segments of the Study Area and the Existing MSW Collection, Data Collection, The Required Number of MSW Bins, and Network Analyst. When the street network was ready, the network analyst approach was carried out to look for the ideal routing system. Two courses were displayed for the best other option. The distance for route A was 7.5 km and the movement time was 15 minutes. The distance and time for route b were twice. Every vehicle required 8 minutes for 4 km from the unloading site back to the parking area. The emission from vehicles during MSW collection and transport was 0.85 g/km.

22. Maraqa M.A. et al (2018) study was carried out in Al Ain City, UAE due to the need for cost minimization of solid waste collection. To cost reduction of waste collection, several routes were been identify to find the best short route for waste collection vehicles with the help of ArcGIS. They approached many restrictions like strictly U-Turn is prohibited. As a result of this restriction, they successfully to saving fuel consumption by 14.3%. they introduced two models for reduced fuel consumption, they were the optimal number and location of

bins. Implementation of model 1, 12% of bins was reduced, on the other hand in Adopting model 2 the number of bins was reduced by 20%. Model 2 proves more efficient in terms of reduction of fuel consumption.

23. Singh N. et al (2018) conducted a study in Gwalior. She studied a try to make a design and develop a proper collection plan with the help of GIS for the selected wards in Gwalior and also the Remarkable reduction in time that can be noticed compared with the existing route in the study area. The city limits of the study area were 423.4sq km. transportation of solid waste was 401 tonnes per day. Route optimization was performed for 10 wards. With the help of this study, they can achieve maximum saving distance and time. The comparison of the existing and optimize route distance generate a saving of 31.25% of distance while the comparison of the existing and optimized route time generates a saving of 31.32%.

24. Yadav R. et al (2019) conducted a study in Kharagpur. He investigates that, they identified collection routes for a minimum of 15 wards of Bilaspur city. Also, take notice of daily variations occurring in waste generation from different sources. They use Network analyst tools which are available in ArcGIS to Optimize solid waste collection routes. The objective of their study is to determine the best route for municipal solid waste collection vehicles and collect all the solid waste generated at the site at the least cost. After their study, they successfully minimized routes by about 26% and 17% reduction in operational cost.

25. Suleman A. et al (2020) conducted a study in UAE. studied that solid waste collection constitutes half of solid waste management costs. Hence, the purpose of this study is that find out the best short route with the help of GIS software to reduce the travel distance of municipal solid waste collection vehicles. The result of the optimization is shown a noticeable difference in existing distance and optimized distance. Travel distance is magnificently reduced from 367.30km to 334.20km. which indicates 9% savings compared to an existing route. If compute this in terms of minutes, without optimization solid waste collection time travel was 1000.75 minutes and if we talked about the optimized collection route travel time is 855.70 minutes which is incredibly low.

26. Niranjan P.T. et al (2022) conducted a study in Mysuru. He performed route optimization to reduce the distance and fuel costs with the help of GIS. They select any random day of the week to develop numerous routes for solid waste management vehicles. They divided Mysuru city into two parts a route of K G Koppal and a route of T K Layout. The existing route for the former one is 19.40km and fuel consumption is 1.03L. After the optimized route by GIS, the reduction was noticed at 15.53km and 0.824L respectively. In the case of later one Existing route is 13.94km and fuel consumption is 0.894L. After the optimized route by GIS, the reduction was noticed at 7.58km and 0.495L respectively.

III. CHALLENGES AND FINDINGS DURING THE STUDY

1. The Municipal Solid Waste Management on Si Chang Island is challenging in terms of its limited land resources, high cost of waste treatment, and seasonal fluctuations in waste volumes However, resilience is shown in the implementation of an integrated approach of waste separation, composting, and incineration. This study developed a complete road network and applied for a network analyst extension, which was useful in the area of optimization of MSW collection and transport. As a result, the Optimized travel distance was reduced 7.5Km from 15Km and the optimized travel time was reduced to 15 minutes from 30 minutes.

2. Waste Management obtains one-third budget of the municipal corporation. They recognized that it could reduce operating costs by improving its use of assets. So, they contracted with the Institute of Information Technology to develop Waste Route. By the end of 2003, Waste Management had 984 fewer routes, saving $18 million.

3. The solid waste Collection cost of municipal solid waste management is the maximum portion of funds allocated for waste management. It can be reduced with the help of the proper strategic decisions regarding the vehicle routing of collection vehicles. The network analyst tool was used in ArcGIS to find the optimized route for solid waste collection considering all the required parameters. After their study, they successfully minimized routes by about 26% and 17% reduction in operational cost.

4. Kolkata city generates a huge amount of solid waste every day it has been difficult to Collect, Handle, Transport, and Recover the solid waste. To deal with this problem they used ArcGIS Desktop to Optimize routes and cut down the cost and increase efficiency. Results indicate that improves workforce management and increases the operational efficiency of Kolkata Municipal Corporation.

5. collection of municipal solid waste is expensive, and to make its Practices effective and efficient, a genetic algorithm was used. After implementing those algorithms compared to the current situation, the truck's total traveled distance was reduced by 66%, whereas, the collection time was also reduced from 7 hours to 2.3 hours per truck trip.

6. In the present day, the collection of waste During peak hours has become a challenging task, which can be solved more effectively by utilizing ArcGIS for better route options. During peak hours waste couldn't be collected due to the size of waste collection trucks and obstacles. However, with the help of Arc GIS Network Analyst, it's possible to estimate interrelations between dynamic factors, like network traffic changes in the area under study, and to produce optimized solutions. It takes into consideration various factors, such as the shortest distance, road network as well as social and environmental implications.

IV. RESULT AND DISCUSSION

RESULT

To accomplish sustainable solid waste management, the review research emphasizes the importance of effective collection and transportation in growing economies. Inadequate solid waste management can have major societal and environmental consequences. It is vital to optimizing collection and transportation through system analysis and operation to reduce total waste management costs and protect the environment. The use of the ArcGIS network analyzer tool to determine optimized solid waste collection routes, decrease travel distance and time, minimize routes, and cut operating expenses, is one example of a successful application of current technology and optimized methodologies. Overall, achieving sustainable solid waste management in emerging economies demands cost savings in collection and transportation, as well as environmental protection.

DISCUSSION

Solid waste management is a global issue that must be tackled urgently, especially in developing countries. Rapid urbanization and population growth have resulted in a rise in solid waste, and poor management can have major environmental and socioeconomic consequences. To accomplish sustainable solid waste management, the review research underlines the importance of effective collection and transportation in growing economies. Using system analysis and operation to optimize collection and transportation is crucial for minimizing total waste management costs while protecting the environment. Effective examples of current innovations and improved methods have been presented, for example, the use of ArcGIS network expert apparatus and high-level calculations, for example, hereditary calculations, to find improved courses for strong waste assortment, diminishing travel distance and time, limiting courses, and decreasing functional expenses. These setups can help to promote circular economy practices and reduce natural consequences. The implementation of these solutions requires a collaborative effort from all stakeholders, including government, industries, and the public.

While implementing regulations and policies to ensure efficient and effective solid waste management, the government can provide incentives for the adoption of modern technologies and optimized techniques. Industries may minimize trash creation by using sustainable practices in their manufacturing processes, while the general people can join in waste reduction initiatives and practice safe garbage disposal. The effective adoption of these solutions can result in various advantages, including lower operating costs, shorter travel distances and times, and increased operational efficiency. Furthermore, promoting circular economy practices can result in job creation, reduced environmental impacts, and improved economic growth. To summarise, attaining sustainable solid waste management in emerging economies necessitates a concerted effort from all stakeholders to guarantee efficient and effective solid waste management while minimizing environmental impact.

V. CONCLUSION

Municipal Solid Waste Management is a complex and challenging issue in many places throughout the world, it demands significant financial resources and innovative solutions. However, successful examples of how modern technologies and optimized techniques can lower operating costs cut travel distance and time, and boost operational efficiency. several studies have utilized the ArcGIS network analyst tool to find optimized routes for solid waste collection, reducing travel distance and time, minimizing routes, and reducing operational costs. Furthermore, the use of advanced algorithms, such as genetic algorithms, can make collection practices more effective and efficient. By utilizing ArcGIS during peak hours, optimized solutions can be produced that take into account various factors such as road networks, social and environmental implications, and traffic changes. Overall, successfully implementing these solutions is crucial for sustainable waste management, reduced environmental impacts, and promoting circular economy practices.

REFERENCES

[1]. Malakahmada A, Khalil N, 2013, Solid waste collection routes optimization via GIS techniques in Ipoh city, Malaysia, Fourth International Symposium on Infrastructure Engineering in Developing Countries, Procedia Engineering 77 (2014), pp. 20 – 27, ISSN 1877-7058

[2]. T.Thangamani, M.Rajamanickam, Das A, Adugna T. GIS Based least cost oath Routing Model for Municipal solid waste: A case study in Kumbakonam, Tamilnadu, International Journal of Scientific & Engineering Research Volume 8, Issue 6, June-2017 pp. 1119-1124, ISSN 2229-5518

[3]. Kamble S, Patil K, Pawar U. GIS in Municipal Solid Waste Management, International Journal of Scientific & Engineering Research Volume 10, Issue 5, May-2019 ISSN 2229-5518

[4]. Paul K, Krishna A.P, Dutta A. A Comprehensive Study on Solid Waste Vehicle Routing and Tracking – a Case Study on Kolkata City, KSCE Journal of Civil Engineering (2016) 20(1):137-144 pISSN 1226-7988, eISSN 1976-3808

[5]. Sahoo s, Kim S, Kim B. Routing Optimization for Waste Management, Vol. 35, No. 1, January–February 2005, pp. 24–36, ISSN 0092-2102

[6]. 6.Verma A, Bhosle B.K. Optimization of Municipal Solid Waste Management of Indore City using GIS, International Journal on Emerging Technologies 5(1):(2014), pp. 194-200 ISSN No: 2249-3255

[7]. Bhambulkar, A.V., (2011). Municipal Solid Waste Collection Routes Optimized with ARC GIS Network Analyst. Advanced Engineering Sciences and Technologies, 11(1), 202-207. Pp. 207-212, ISSN 2230-7818

[8]. Christos C., Lasaridi K. A GIS-based model for the optimization of municipal solid waste collection: The case study of Nikea, Athens, Greece, WSEAS Transactions on Environment and Development Issue 10, Volume 5, October 2009, Pp. 639-650 ISSN: 1790-5079
[9]. Bhambulkar A.V, Khedikar I. P. Municipal solid waste collection route for Laxmi Nagar by Geographical information system, International Journal of Advanced Engineering Technology, Vol.2, Issue 5, October-December 2011, Pp 48-53, ISSN 0976-3945
[10]. Shoba B, Dr. Rasappan K. Application of GIS in Solid Waste Management for Coimbatore City, International Journal of Scientific and Research Publications, Volume 3, Issue 10, October 2013, ISSN 2250-3153
[11]. Itnal B.N, Prakash S.M. Route optimization of community solid waste management in selected wards of Bangalore city using Geographical information system IJRET: International Journal of Research in Engineering and Technology, Volume: 04 Issue: 11, Nov-2015, Pp. 232-238, eISSN: 2319-1163, pISSN: 2321-7308
[12]. Nemade P. A GIS-Based route optimization for solid waste management: A case study on Indapur Municipality, International Journal of Advanced Research 5(12), December 2017, Pp. 1427-1436, ISSN: 2320-5407
[13]. Patel H, Padhya H, Zaveri P. GIS-Based Route Optimization for Solid Waste Management: A Case Study of Surat City, IJSRD - International Journal for Scientific Research & Development Vol. 4, Issue 04, 2016, Pp. 32-35, ISSN: 2321-0613
[14]. Nagrale S.D., Khedkar S, Rangdal A, Patil S. Route Optimization of Solid Waste by using ArcGIS Application in Pune, India, IJSTE - International Journal of Science Technology & Engineering, Volume 4, Issue 12, June 2018, Pp. 7-10, ISSN: 2349-784X
[15]. Gowda M.K., Niranjan P.T. Optimal Routing of Municipal Solid Waste collection vehicle in Selected wards of Mysore City using GIS, International Research Journal of Engineering and Technology (IRJET), Volume: 09 Issue: 08, Aug 2022, Pp. 2029-2032, e-ISSN: 2395-0056, p-ISSN: 2395-0072
[16]. Singh N, Agrawal A.K. Route Optimization for Municipal Solid Waste Collection using ArcGIS Application in Gwalior City, Madhya Pradesh, International Journal for Research in Applied Science & Engineering Technology (IJRASET) Volume 6 Issue 7, July 2018, Pp. 392-398, ISSN: 2321-9653
[17]. Chaikaew p., Route Optimization of MSW Collection and Transport Using a GIS-Based Analysis on the Tourism Island, Sustainability in Environment, Vol. 3, No. 3, 2018, Pp. 197-206 ISSN 2470-6388
[18]. Paul K., Krishna P., A Comprehensive Study on Solid Waste Vehicle Routing and Tracking – a Case Study on Kolkata City, KSCE Journal of Civil Engineering (2016) 20(1), Pp. 137-144, p-ISSN 1226-7988, e-ISSN 1976-3808
[19]. Yadav R., Rathore P., Development of Vehicle Routing model in Urban Solid Waste Management system under periodic Variation: A Case study, IFAC (International Federation of Automatic Control), Pp. 1961-1965, ISSN 2405-8963
[20]. Malakahmad A, Khalil N D. Solid waste collection system in Ipoh city: a review, In Kuala Lumpur 2011, International Conference on Business, Engineering and Industrial Application - Proceedings, IEEE 2011, Pp. 174-179, ISBN 978-14-57712-78-4
[21]. Malakahmada A., Solid waste collection system in Ipoh city: A Review, 2011 International Conference on Business, Engineering and Industrial Applications (ICBEIA), Pp. 173-179
[22]. paydin O, Gonullu M T. 2008. Emission control with route optimization in solid waste collection process: a case study. Sadhana Vol. 33, Part 2, April 2008, pp. 71–82.
[23]. Vrushketu A., Bhambulkar., Municipal solid waste collection Routes optimized with arc GIS network analyst, International Journal of Advanced Engineering Sciences and Technologies, Vol. No. 11, Issue No. 1, Pp. 202 – 207, ISSN: 2230-7818
[24]. Verma A., Bhonde B.K., Optimization of Municipal Solid Waste Management of Indore City using GIS. International Journal on Emerging Technologies 5(1), Pp. 194-200, ISSN: 2249-3255
[25]. Sanjeevi V., Shahabudeen P., Optimal routing for efficient municipal solid waste transportation by using ArcGIS application in Chennai, India, Waste Management & Research
[26]. Singh N., Kumar A., Route Optimization for Municipal Solid Waste Collection using ArcGIS Application in Gwalior City, Madhya Pradesh, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 6 Issue 7, July 2018, Pp. 392-398, ISSN: 2321-9653
[27]. Omer Apaydin (2007) Route optimization for solid waste collection: Trabzon (Turkey) case study, Global NEST Journal, Vol 9, No 1, pp 6-11
[28]. 28. Zsigraiova Z., Semiao V., A case study of fuel savings through optimization of MSW transportation routes, Management of Environmental Vol. 19 No. 4, 2008, pp. 444-454, ISSN: 1477-7835