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A Review on Route Optimization of Municipal Solid Waste Collection in Jabalpur city using ARC GIS

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ABSTRACT

Uncontrolled growth of the urban population in developing countries in recent years has made solid waste management an important issue, so the system for collection of solid waste thus constitutes an important component of an effective solid waste management system. Waste collection become more complex in developed countries in terms of logistic, fuel , labor cost and air pollutants emission. In this study, solid waste collection routes optimization using Geographical Information System (GIS Arc View) was investigated. The present route were optimized to reduce the length of the routes and consequently the time taken to complete the collection. The problem of waste collection in Jabalpur city has been considered where sources are dispersed by varied way. In this work, the waste transportation problem for time and cost effective waste management system design has been carried out. The present study is to analysis the various research papers to optimize a route upgrading associated with the current routes taken by the solid waste collection trucks in the Rampur area (Jabalpur); and shows a better performance in terms of fuel consumption, emissions from the trucks and less operational costs, making it a solution to urban environmental management.

Keywords: Municipal solid waste management, waste collection , Route Optimization, urban area, Arc GIS software , Geographical Information System (GIS).

I. INTRODUCTION

Solid waste generated by the daily activities of the people needs to be properly managed in such a way that it minimizes the risk to the environment and human health. Inadequate collection and disposal of solid waste is a major factor in the spread of disease and environmental degradation. One of the most visible problems in the provision of solid waste management (SWM) is the collection route developed and save the cost of fuel and time of service of the solid waste, which is the subject of this paper. Solid waste management is undoubtedly an increasingly important element in terms of efficiency and profitability for any municipality .The routing optimization problem in waste management has been already explored with a number of algorithms. Moreover, the successful implementation of vehicle routing software has been aided by the exponential growth in computing power since 1950, the emergence of accurate and sophisticated Geographic Information Systems (GIS) technology induced multiple algorithmic solutions.

Solid waste management today is made difficult and costly by the increasing volumes of waste produced, the need to control what are now recognized as potential serious environmental and health effects of disposal, the lack of land in urban areas for disposal purposes, partly due to public opposition to proposed sites. Waste management, once strictly a local and private sector matter, now involves regional, state and federal authorities. Various legislative initiatives and procedures have been activated within the last few years in the leading industrial countries.' The two primary reasons to have solid waste management on a regional instead of on the level of local towns and cities, which is the current practice, are economical and technical and political feasibility.

II. Objective of the Study

The objective of the present study is to give a ***review*** about how to reduce the amount of the exhaust emissions from trucks used in solid waste collection process by means of optimized routes based on various research papers as well as practical conditions.

Description of city of Jabalpur

Jabalpur lies on the banks of the Narmada River and sprawls over the plains of its tributaries Hiran, Gaur, Ken &Sone. Geographically, the city is located at 23°10' North latitude and 79°57' East longitude, at an altitude of 393 meters above mean sea level. The topography of Jabalpur is unique.The territorial jurisdiction of the municipal corporation spans 106.19 sq. km.The current (2011) population of Jabalpur is 1.82 million (2017). The city has experienced relatively moderate growth rates in population during the last two decades- 1981-91 & 1991-2001.The population density of Jabalpur is 478 persons per square kilometer.The district is divided in 13 zones and 79 wards.In this research work, a Giriraj Kishore ward was chosen as the case study area Which comes under zone three that is Rampur zone. The ward no is 11 the population of the ward is 16,349 and the number of households in this ward is 2,629 as per 2011 census.

III. Literature Review based on previous study

The sheer amount of Municipal Solid Waste (MSW) produced from residential and commercial activities has posed a big threat to the modern society, especially to large cities by causing environmental issues such as greenhouse gas emission, leakage of leachate and contamination of air, soil and water resources. The urban managers are keen on improving MSW management to mitigate the environmental impacts and to improve the sustainability of their cities.

Ali Mirdar Harijani et al (2017) proposes a systematic approach to build an integrated recycling and disposal network for MSW by explicitly considering the sustainability with an objective to maximize the total profit with a budget constraint. A multi-period mixed integer linear programming model was proposed to design the network optimally as well as to optimally operate the network. The optimization model involves decisions related to facilities selection, capacity level and location of facilities, allocation of solid waste to facilities, transportation of waste among facilities and distribution of recycled materials. This paper also extended the developed social life cycle assessment methodology to model the social impacts of the network. The model was applied to a real-world case in Tehran, Iran, and could provide the profit of USD 43.49 M over a five-year planning period. In order to show the impacts of sustainability and budget limitations, the model was compared with three models: I) the model without sustainability, II) the model without budget limitations and III) the model without sustainability and budget limitations. The models I and III led to the loss of USD -308.60 and - 362.80 M, which are not desirable. This shows the consideration of sustainability will improve the profit in the long term. The model II could provide the profit of USD 99.73 M over a five-year planning period, indicating that limited budget have significant impact on the way the recycling network is operating.

Angelina Vitorino de Souza Melaré et al (2016) presents a systematic review on scientific publications concerning decision support systems applied to Solid Waste Management (SWM) using ICTs and OR in the period of 2010–2013. A statistical analysis of the eighty seven most relevant publications is presented, encompassing the ICTs and OR methods adopted in SWM, the processes of solid-waste management where they were adopted, and which countries are investigating solutions for the management of solid waste. A detailed discussion on how the ICTs and OR methods have been combined in the solutions was also presented.

A mathematical model which adopts integer linear programming and mixed integer programming has been developed by ***C.K.M. Lee et al (2016)*** for Hong Kong municipal solid waste management. A sensitivity analysis was carried out to simulate different scenarios which provide decision-makers important information for establishing Hong Kong waste management system.

Xiaoyun Bing et al (2015) compares municipal solid waste (MSW) management practices in various EU countries to identify the characteristics and key issues

from a waste management and reverse logistics point of view. Further, we investigate literature on modelling municipal solid waste logistics in general. Comparing issues addressed in literature with the identified issues in practice result in a research agenda for modeling municipal solid waste logistics in Europe. Author conclude that waste recycling is a multidisciplinary problem that needs to be considered at different decision levels simultaneously.

Christian Riuji Lohri et al (2014*)* presents a cost-revenue analysis, based on data from July 2009 to June 2011. The analysis reveals that overall costs in Bahir Dar's SWM system increased significantly during this period, mainly due to rising costs related to waste transportation. On the other hand, there is only one major revenue stream in place: the waste collection fee from households, commercial enterprises and institutions.

As the efficiency of fee collection from households is only around 50%, the total amount of revenues are not sufficient to cover the running costs. The results of thr research therefore how that a more detailed cost structure and cost -revenue analysis of this waste management service is important with appropriate measures, either by the privates sector itself or with the support of the local authorities, in order to enhance cost efficiency and balance the cost- revenues towards cost recovery. Delays in mitigating the evident financial deficit could else endanger the public-private partnership (PPP) and lead to failure of this setup in the medium to long term, thus also endangering the now exiting improved and currently reliable service. Author presents four options on how financial sustainability of the SWM system in Bahir Dar might be enhanced: (i) improved fee collection efficiency by linking the fees of solid waste collection to water supply; (ii) increasing the value chain by sales of organic waste recycling products; (iii) diversifying revenue streams and financing mechanisms (polluter-pays-, crosssubsidy-and business-principles); and (iv) cost reduction and improved cost-effectiveness.

H.A. Eiselt & Vladimir Marianov, (2014) introduces the landfill siting problem by way of (usually ill-fated) examples. It then discusses different classes of decision-making models and formulates a generic cost-minimization model for that purpose. It continues to describe some multi-criteria decision models that have been used for landfill siting. The paper then surveys landfill location models that have appeared in the literature during the last forty years. The work concludes with a framework that "zooms in" and uses existing techniques to determine sites for solid waste facilities.

Davide Anghinolfi et al (2013)focused on recycling management and on the dynamic optimization of materials collection. The developed dynamic decision model is characterized by state variables, corresponding to the quantity of waste in each bin per each day, and control variables determining the quantity of material that is collected in the area each day and the routes for collecting vehicles. The objective function minimizes the sum of costs minus benefits. The developed decision model is integrated in a GIS-based Decision Support System (DSS). A case study related to the Cogoleto municipality presented to show the effectiveness of the proposed model. From optimal results, it has been found that the net benefits of the optimized collection are about 2.5 times greater than the estimated current policy.

Katja Buhrkal et al (2012) study the Waste Collection Vehicle Routing Problem with Time Window which is concerned with finding cost optimal routes for garbage trucks such that all garbage bins are emptied and the waste is driven to disposal sites while respecting customer time windows and ensuring that drivers are given the breaks that the law requires. Author propose an adaptive large neighbourhood search algorithm for solving the problem and illustrate the usefulness of the algorithm by showing that the algorithm can improve the objective of a set of instances from the literature as well as for instances provided by a Danish garbage collection company.

The sustainability of the waste management in the city of London is attributed to the continuous improvement strategy framework adopted by the city based on the principles of integrated waste management. It is perceived that adopting a strategic framework based on the principles of integrated waste management with a strong political and social will, can transform the current waste management in Kumasi and other cities in developing countries in the bid for finding lasting

solutions to the problems that have plagued the waste management system in these cities.

Solid waste collection and hauling account for the greater part of the total cost in modern solid waste management systems. In a recent initiative 3,300 Swedish recycling containers have been fitted with level sensors and wireless communication equipment thereby giving waste collection operators access to real-time information on the status of each container. In a previous study (Johansson, 2006), analytical modeling and discrete –event simulation have been used to evaluate different scheduling and routing policies utilizing the real-time data, and it has been shown that dynamics scheduling and routing policies exist that have lower operating costs, shorter collection and hauling distances, and reduced labor hours compared to the static policy with fixed routes and pre-determined pick-up frequencies employed by many waste collection operators today. Ola M. Johansson and Rolf Johansson (2008) study further refining the scheduling and routing policies by employing a model predictive control (MPC) framework on the system. In brief, the MPC controller should minimize an objective cost function consisting of fixed and variable collection and hauling costs for a fixed future horizon by calculating sequence of tactical scheduling and routing decisions that satisfies system constraints using a receding horizon strategy.

Solid waste collection processes are usually carried out by using truck with diesel engine. In solid waste collection process, the trucks emit to environment different emissions from its exhausts. For this reason, in solid waste collection process, it is necessary that route optimization should be performed in order to decrease the emissions. The study was performed by Omer Apaydin and M Talha Gonullu (2008) in Trabzon city with 39 districts, a shortest path model was used in order to optimize solid waste collection/hauling process, emissions increase due to empty miles negativeness. A software was used as an optimization tool. The software provided Geographical Information System (GIS) elements such as numerical pathways, demographic distribution data, container distribution data and solid waste production data. In addition, thematic container layer was having 777 points for the entire city. By using the software, the optimized route was compared with the present route. If the optimized route in solid waste collection system is used, route distance and route time will be decreased by 24.6% and 44.3% as mean of nine routes, respectively. By performing the stationary container collection process and route optimization, it is determined that CO_2, NO_2 , NO_X ,HC , CO , PM emissions will be reduced 831.4, 12.8, 0.4, 0.7 g per route, respectively.

IV. Municipal solid waste management system overview in Jabalpur city

The primary sources of solid waste in Jabalpur City are local households, markets, commercial establishments, hotels, restaurants, and hospitals. The total quantity of waste generated per day is in the order of 411 tons at the rate of 432 gpcd. In the absence of significant tourism-related activity, there is no significant seasonal variation in the quantity of waste generated. The MCJ is responsible for collection, transportation and disposal of all solid waste generated in the city, except the untreated bio-medical waste and hazardous industrial waste, which is the responsibility of respective generators. MCJ has a network of community level waste collection points, the majority of which are in the form of open grounds. The Corporation organizes the collection and transportation through a team of its own conservancy workers and a fleet of vehicles and dumper-placers. The Corporation has also privatized waste collection and transportation activities in some wards of the city. The waste collected is disposed at dumping yards on the outskirts of the city without any treatment. A number of rag pickers make their livelihood by salvaging recyclable waste from collection points and dump yards. The Health Department of the Corporation is vested with the responsibility of day-to-day solid waste collection and disposal. The estimated quantity of waste collected and disposed is about 330 tons per day - a collection performance of about 70 per cent.

A. Waste Generation

In Jabalpur, about 450 metric tonnes of solid waste is generated from both household and commercial sources. On the average, 0.432 kg per capita of household solid waste is generated in the city of Jabalpur per day. In the year 2017, a total of 450 metric tonnes of both residential (58%) and non-residential (42%) waste was managed in the city of Jabalpur. It is estimated that

households generate the highest amount of waste, followed by Markets, then industries with the least from institutions although the exact proportions could not be provided.The waste generation rate in the municipality is expected to increase by 15% by the year 2020.

B. Waste Composition

The composition of household waste in the city of Jabalpur is shown in Table 3.1.

(S.P. Gautam et al)

S.NO.	Components	High % (by weight)	Middle	Low
1.	Paper	9	6	4
2.	Plastic/Polythenes	14	17	21.4
3.	Textiles	1.5	3	2
4.	Rubber	1	2	1.2
5.	Metal	0.8	0.5	0.3
6.	Glass	3.2	4.2	1.3
7.	Food wastes	30.2	28.5	24.4
8.	Soil	38.5	37.3	42.2
9.	Miscellaneous	1.8	1.5	3.2

Table 3.1. Composting of municipal solid waste in high, middle and low socioeconomic localities

C. Government law and regulation

Legislation concerning waste is usually differentiated according to the type of waste. International conventions often cover nuclear and hazardous waste, whereas nonhazardous waste, often called solid waste is usually more regulated at the national level. From an environmental angle the following environmental rules, regulations and acts would be the most relevant for MSWM:

1. Municipal Solid Waste (Management & Handling) Rules 2000, notified by the ministry of Environment and Forests, Government of India vide notification No. S.O.908 (E) dated 25th September 2000. The guidelines given in this law covers all the functional elements of municipal solid waste management.
2. The Water (Prevention and Control of Pollution) Act, 1974. Two aspects have to be kept in mind of this law in regard to MSWM. Firstly, a consent from the state pollution control board for establishment of a sanitary landfill site and compost plant is essential and secondly, no water pollution should be caused by the leachate that is emitted by the sanitary landfill site or a compost plant.
3. The Water (Prevention and Control of Pollution) Cess Act, 1977 and amendments thereon. The only aspect that should be considered in this law in regard to MSWM is provision for levying and collection of cess on water consumed for the sanitary landfilling, composting and anaerobic digesters.
4. The Air (Prevention and Control of Pollution) Act, 1981 and amendments thereon. The aspects to be considered in this law with respect to MSWM is the need for obtaining consent from the State Pollution Control Board for establishment of the processing plants and disposal site and from an environmental aspect would be the pollution caused by incineration plants, compost plants and landfill sites.
5. The Environmental (Protection) Act, 1986 and its subsequent notifications. The aspect in regard to MSWM would be the EIA notification, 1944, which states that for any project to be authorized an EIA report should be submitted first.

D. Challenges for MSWM in Jabalpur as enumerated by city authority

Current challenges to waste management in city authority's face are:

1. Inadequate funding for capital investment for effective delivery of waste management services.
2. Inadequate equipment holding culminating in limited coverage of service delivery
3. Inadequate bye-laws and lack of enforcement of available ones.
4. Inadequate revenue mobilization to finance Waste Management Service costs.
5. Bad attitude of residents such as indiscriminate disposal of household waste and littering due to lack of effective environmental health education and service promotion strategy.
6. Poor infrastructure, particularly road networks and waste collection points, mostly in new settlements, which impacts negatively on service delivery.

V. Conclusion

At present study, it is analyse on the base various research paper how the waste collection and transportation problem considered which is arising when planning an effective waste management system. The

problem of waste collection in Jabalpur city has been considered where sources are dispersed by varied way. In this work, the waste transportation problem for time and cost effective waste management system design has been proposed out.

VI. REFERENCES

[1]. Angelina Vitorino de Souza Melare , Sahudy Montenegro Gonzalez, Katti Faceli, Vitor Casadei,2016, "Technologies and decision support systems to aid solid-waste management: a systematic review", http://dx.doi.org/10.1016/j.wasman.2016.10.045 .

[2]. Asase, M., Yanful, E.K., Mensah, M., Stanford, J., Amponsah, S., 2009. "Comparison of municipal solid waste management systems in Canada and Ghana: a case study of the cities of London",Ontario, and Kumasi, Ghana. Waste Management. 29, 2779-2786.

[3]. Ali Mirdar Harijani, Saeed Mansour, Behrooz Karimi, Chi-Guhn Lee, 2017, "Multi-period sustainable and integrated recycling network for municipal solid waste – A case study in Tehran", Journal of Cleaner Production (2017), doi: 10.1016/j.jclepro.2017.03.030.

[4]. C.K.M. Lee, C.L. Yeung, Z.R. Xiong, S.H. Chung, 2016, "A mathematical model for municipal solid waste management – A case study in Hong Kong", http://dx.doi.org/10.1016/j.wasman. 2016. 06. 017.

[5]. Christian Riuji Lohri,Ephraim Joseph Camenzind,Christian Zurbrugg,2014,"Financialsustainability in municipal solid waste management–Costs and revenues in Bahir Dar,Ethiopia" Waste Management 34 (2014) 542–552.

[6]. Davide Anghinolfi , Massimo Paolucci , Michela Robba , Angela Celeste Taramasso, 2013, "A dynamic optimization model for solid waste recycling", http://dx.doi.org/10.1016/j.wasman. 2012. 10.006.

[7]. Guo, P., Huang, G.H., 2009. Inexact fuzzy-stochastic mixed-integer programming approach for longterm planning of waste management– Part A: Methodology. Journal of Environmental Management.91, 461-470.

[8]. Gianpaolo Ghiani, Andrea Manni, Emanuele Manni , Massimiliano Toraldo, 2014, "The impact of an efficient collection sites location on the zoning phase in municipal solid waste management",http://dx.doi.org/10.1016/j.wasman.2014.05.026.

[9]. H. W. Gottinger 1985. A computational model for solid waste management with applications. Appl.Math. Modelling, 1986, Vol. 10, October.

[10]. Hoornweg, D., Bhada-Tata, P., 2012. What a Waste: A Global Review of Solid Waste Management.Urban development and local government unit, The World Bank, Washington, DC. go.worldbank.org/BCQEP0TMO0 (accessed 12.10.16).

[11]. H.A. Eiselt & Vladimir Marianov, 2014, "Location Modeling for Municipal Solid Waste Facilities",http://dx.doi.org/10.1016/j.cor.2014.05.003.

[12]. Basavaraj N Itnal1, S M Prakash2. "ROUTE OPTIMIZATION OF COMMUNITY SOLID WASTE MANAGEMENT IN SELECTED WARDS OF BANGALORE CITY USING GEOLOGICAL INFORMATION SYSTEM (GIS)" ,http://esatjournals.net/ijret/2015v04/i11/IJRET20150411040.pdf.

[13]. Kanat, G., 2010. Municipal solid waste management in Istanbul. Waste Management. 30, 1737-1745.

[14]. Katja Buhrkal, Allan Larsen, Stefan Ropke, (2012), "The waste collection vehicle routing problem with time windows in a city logistics context", Procedia - Social and Behavioural Sciences 39 (2012)241 – 254 1877-0428 7th International Conference on City Logistics doi: 10.1016 / j.sbspro. 2012.03.105, the Seventh International Conference on City Logistic.

[15]. Mizpah Asase, Ernest K. Yanful, Moses Mensah, Jay Stanford, Samuel Amponsah, 2009, "Comparison of municipal solid waste management systems in Canada and Ghana: A case study of the cities of London, Ontario, and Kumasi, Ghana".

[16]. McDougall, F., White, P., Franke, M., Hindle, P., 2001. Integrated Waste Management: A Life Cycle Inventory, second ed. Blackwell Science, Oxford, UK, ISBN: 0 632 05889 7 (03/11208).

[17]. Ola M. Johansson, Rolf Johansson, 2008, "Model Predictive Control for Scheduling and Routing in a Solid Waste Management System", Proceedings of the 17th World Congress the International Federation of Automatic Control Seoul, Korea, July 6-11, 2008.

[18]. S.P. Gautam, P.S. Bundela, A. K. Pandey, M.K.Awasthi and S. Sarsaiya, 2010, "Composting of Municipal Solid Waste of Jabalpur City", Global Journal of Environmental Research 4 (1): 43-

46,2010 ISSN 1990-925X © IDOSI Publications, 2010.

[19]. Talyan, V., Dahiya, R.P., Sreekrishnan, T.R., 2008. State of municipal solid waste management in Delhi, the capital of India. Waste Management. 28, 1276-1287

[20]. United Nations Environment Programme (UNEP), 2005. Solid Waste Management, vol. I, ISBN: 92-807-2676-5.

[21]. Wolfsberger, T., Pinkel, M., Polansek, S., Sarc, R., Hermann, R., Pomberger, R., 2016. Landfill mining: Development of a cost simulation model. Waste Management & Research. 34: 356-367.

[22]. Wilson, D.C., 2007. Development drivers for waste management. Waste Management and Research 25, 198–207.

[23]. Xiaoyun Bing , Jacqueline M. Bloemhof , Tania Rodrigues Pereira Ramos , Ana Paula Barbosa-Povoa,Chee Yew Wong, Jack G.A.J. van der Vorst, 2015, "Research challenges in municipal solid waste logistics management", http://dx.doi.org/10.1016/j.wasman.2015.11.025.

[24]. Zurbrugg, C., Schertenleib, R., 1998. Main problems and issues of municipal solid waste management in developing countries with emphasis on problems related to disposal by landfill. Presented at Third Swedish Landfill Research Symposia, Lulea, Sweden, and October 1998.

[25]. Mariana Soares Maciel Machado Magalhaes, "Route Optimization for the Solid Waste Collection"https://paginas.fe.up.pt/~ee05135/MT/MT%20%20Mariana%20Magalhaes%20(050503135).pdf.

[26]. Amirhossein Malakahmada, Putri Md Bakria, Munirah Radin Md Mokhtara, Noordiana Khalila, "Solid waste collection routes optimization via GIS techniques in Ipoh city, Malaysia ", https://www.sciencedirect.com/science/article/pii/S1877705814010005 .

[27]. Danijel Markovic, Dragoslav Janosevic, Miomir Jovanovic, Vesna Nikolic, "APPLICATION METHOD FOR OPTIMIZATION IN SOLID WASTE MANAGEMENT SYSTEM IN THE CITY OF NIs "http://facta.junis.ni.ac.rs/me/me201001/me201001-08.pdf.

[28]. Mr. Ankit Verma and Prof. B.K Bhonde, "Optimisation of Municipal Solid Waste Management of Indore City using GIS", https://www.researchtrend.net/ijet/ijet31/36%20ANKIT%20VERMA.pdf.

[29]. Mohana Taneja#1,Archana Paranjpe#2,"MSW USED AS ENERGY RECOVERY IN JABALPURCITY", http://www.ijater.com/Files/6e2b4d67-f7f04e7e975d4c9a522718 44_IJATER_35_03.pdf

[30]. NIKOLAOS V. KARADIMAS MARIA KOLOKATHI GERASIMOULA DEFTERAIOU VASSILI LOUMOS , "MUNICIPAL WASTE COLLECTION OF LARGE ITEMS OPTIMIZED WITH ARC GIS NETWORK ANALYST " , http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.462.6532&rep=rep1&type=pdf

[31]. Jabalpur Municipal Corporation, Madhya Pradesh, India With Sacramento County, California, USA , "Improved solid waste management in Jabalpur, a case study " , http://www.umcasia.org/uploads/Citylinks_Jabalpur_case_study_Improved_solid_waste_management_in_Jabalpurpdf.pdf.

[32]. A.V.Bhambulkara Isha.P. Khedikarb, "MUNICIPAL SOLID WASTE (MSW) COLLECTION ROUTE FOR LAXMI NAGAR BY GEOGRAPHICAL INFORMATION SYSTEM(GIS)" , https://s3.amazonaws.com/academia.edu.documents/33184805/Asthashil.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1510767307&Signature=Uhlr4JUbNqazdJf2%2BKr3TBFVPwM%3D&response-contentdisposition=inline%3B%20filename%3D International_Journal_of_Advanced_Engine.pdf

[33]. Hareesh K.B1 , Manjunath N.T 2 , Nagarajappa D.P.3 , "Route Optimization of Municipal Solid Waste for Davangere City Using GIS " , https://www.ijirset.com/upload/2015/june/5_Route_NEW.pdf

[34]. CHRISTOS CHALKIAS, KATIA LASARIDI ,Department of Geography , "Optimizing municipal solid waste collection using GIS " , http://www.wseas.us/elibrary/conferences/2009/vouliagmeni/EELA/EELA-03.pdf.

[35]. Central Public Health and Environmental Engineering Organisation (CPHEEO),MUNICIPAL SOLID WASTE MANAGEMENT MANUAL. http://sac.ap.gov.in/sac/UserInterface/Downlaods/MSWMReports/Book%202.pdf.