ABSTRACT

Municipal solid wastes, commonly known as trash or garbage, are the solid wastes generated from human activities. Some of these wastes are extremely toxic and infectious. The uncontrolled and unscientific way of dumping such wastes have raised the number of incidents of hazards to human health. One of the important aspects which gains more impact on sustainability of environment is management of municipal solid waste. The efficient functioning of Municipal Solid Waste Management (MSWM) needs the participation of both the municipal authorities and the public.

Solid waste in India poses a dreadful challenge to corporation/municipal authorities today and it is roughly estimated that the country produces 30 million tones of urban solid waste annually. The share of urban population in our country’s total population is about 27 percent and the per capita waste varies between 0.1 kg/day and 0.6 kg/day, with an average of 0.33 kg/day (Bhide, 1990). Prevailing management strategies are inefficient, because of their complexity, cost and lack of technology, and avoidance of solid waste management’s socio-economic and ecological characteristics. Improper management of these wastes leads to public health hazards, unaesthetic appearance, and pollution of soil, air and water sources like lakes, ground water, etc. The lack of stakeholder participation and inadequate organizational framework also leads to inefficient handling of waste. In order to improve the present practice and to avoid environmental degradation, an attempt is made in this study to arrive at an optimal route for transporting the municipal solid waste.
A case study of Madurai Corporation (MC) has been selected for effective and efficient management of municipal solid waste. The main objective of the research is to find optimal route for transporting the garbage from dumper bins and also from temporary transfer stations to the final dumping yard. Out of the 72 wards in MC, ward numbers 13, 27, and 47 have been chosen as pilot study area for developing a feasible solid waste management model called Vehicle Routing Problem with Time Window (VRPTW). This model can be replicated in any urban area in developing countries. Quantification of various wastes from different sectors through field investigations covering waste generation, mode of collection, type of road, traffic condition, etc. have been carried out. In addition to street littering, waste generated in hotels, restaurants, marriage halls, market places have also been quantified through field analysis. Based on the detailed field observations, strategies for quantification to arrive at the precise quantity of waste generated (attribute information), and effective use of Geographical Information System GIS (layers with feature data clause) and the optimal management strategy of MSW are proposed. The management options are proposed with the help of available guidelines from literature, synthesized and modified according to the prevailing conditions. A regression analysis of the data helps finding the accuracy and dependability of the data handled. A correlation analysis has been carried out to find the correlation between the actual and the theoretical quantity of garbage and it is found that the value of correlation coefficient is 0.89 which means that a good co-relation exists between the population and the actual garbage generation.

The Ministry of Environment and Forests, Govt. of India, notified the Municipal Solid Waste (Management and Handling) Rules, 2000, realizing the need for proper and scientific management of solid waste. The
objective of these rules was to make every municipal authority responsible for the implementation of the various provisions of the rules within its territorial area and also to develop an effective infrastructure for collection, storage, segregation, transportation, processing, and disposal of Municipal Solid Wastes (MSW). The indiscriminate dumping of MSW in water bodies and low lying areas is a common practice followed by most of the municipalities with no consideration for its effect on the environment.

The research work has been carried out in two stages, namely data collection in the first stage and data analysis for optimization in the second stage. For finding the optimal transportation route, VRPTW model is utilized in the GIS and GA environments. The proposed study is focused on finding the optimal route in transporting the MSW from dumper bins and temporary transfer stations to the dump-yard.

This research work addresses how the VRPTW model works on GIS and GA environments. Firstly, the use of GIS tool for the logistic analysis of MSW transportation from bins and temporary transfer station to the dump-yard is carried out. The spatial road network of MC is integrated with the attribute data of population, quantity of garbage generated, bin capacity, type of road, lane of road, traffic volume, etc. The optimal routes for the transportation of garbage bins and also for the temporary transfer stations are arrived at using the VRP tool in Network Analyst (NA) module of ARCGIS9.3. The optimal routes are arrived at based on the garbage generated in the present area of study. Constraints like one-way, loading gauge are also honored in the optimal routes. Each ward is assigned a time window for effective logistic management. The results obtained for various time windows shows 5% saving for 1 dumper placer vehicle per trip in the transportation and maintenance cost as compared with the existing system. MC needs to
operate 90 such vehicles in 6 trips. Major of the total amount is spent on transportation of MSW by municipalities/corporations. It is evident from this that the resources and labors are utilized efficiently by using specific time window.

Secondly, one of the evolutionary optimization tools, Genetic Algorithm (GA) is used for finding the optimal routes in the study area. The cost of transportation of municipal solid waste from the bins and temporary transfer site are arrived at by using the coding developed in C programming for VRPTW model. The total cost of transportation is assumed as the sum of transportation cost and the fixed cost (which includes the maintenance and labor cost) and the same is compared with the existing system.

The thesis addresses the application of VRPTW model in GIS and GA environment individually. It is evident from the output that the results of GIS will be best suited for the municipality where the top official can monitor and control the municipal activities from one central place due to its visualization. The results produced by GA are near optimal because it is based on theoretical approach.

The present work introduces a structured frame work for the logistics of municipal solid waste management, helps the MC officials for monitoring, and also selects alternate routes during the natural and/or manmade hindrances in logistics without disturbing the entire system. When time window is used for vehicle routing, resources like labors and vehicles can be effectively managed and utilized. Because of the time window, it is easier for the top level officials to manage both labors and transportation vehicles.
GIS is expected to bring reforms in terms of clarity on the concepts of data management and analysis using the uniquely designed innovative GIS platform. The corporation officials involved in the solid waste management will be clear about the functions and their role in terms of managing the cities efficiently with the help of GIS system. There will be a complete inventory of the things associated with SWM; proper logistics management and spatial planning can be done using the GIS analysis based on various generated feature clauses about the SWM issues for implementing and managing the system at field level.