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IMPROVEMENT OF SOLID WASTE COLLECTION BY USING OPTIMIZATION TECHNIQUE

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ABSTRACT

In the present paper, the Optimization technique is used for the identification of optimal routes in the case of Municipal Solid Waste (MSW) collection. The identification of a route for MSW collection trucks is critical since it has been estimated that, of the total amount of money spent for the collection, transportation, and disposal of solid waste, approximately 60-80% is spent on the collection, therefore a small improvement in the collection operation can result to a significant saving in the overall cost. The proposed collection system is based on positions of waste bins, the road network and the population density in the area under study. In addition, waste collection schedules, truck capacities and their characteristics are also taken into consideration. Minimal spanning tree technique is used to locate the shortest possible routes to collect waste from all dustbins in the study region. It is possible to collect 100% waste from the area of study by using alternating suitable methods of collection. The objective of the system is to identify the most cost effective system for solid waste collection, and compare it with the existing methods adopted by the municipal authority doing cost analysis of both.

INTRODUCTION

Urbanization is a world wide phenomenon. This process of urbanization is very rapid, the urban population of India is likely to be 30 million in 2001 and 395 million by 2011 AD. India and many other countries are suffering from all the problem of urbanization. These high densities Community create challenge in the provision of potable water supply, clean air, and waste disposal. Hence it is important to recognize the impact which urbanization and industrialization has on environment, one of the important impacts of the 'solid waste'.[3]

Optimization routes for MSW collection trucks is important since it has been estimated that, of the total amount of money spent for the collection, transportation, and disposal of solid waste, approximately 60-80% is spent on the collection. Therefore, a small improvement in the collection operation can result to a significant saving in the overall cost. The present paper mainly focuses on the collection and transport of solid waste from any loading spot in the area under study. In addition, other factors that affect the whole system will be mentioned and discussed. Of course, this research covers only the routes included in the given area, but can be applied to any other area.

According to this system, the optimization is introduced and implemented, for defining the optimal collection route. In the end, the results of the minimal spanning tree are also compared with the empirical method that the Municipality of Kolhapur uses to collect and transport the solid waste to the disposal site. This technique is described in the rest of the paper, first the theoretical and methodological aspects for urban solid waste management and the related work that has been done in this area is described. This is followed by an introduction to the waste management problem in the selected case study area. Thereafter the optimization solution is introduced and implemented for the area under study. The results of the Minimal spanning tree and its comparison with the present method used by the municipal authority of Kolhapur city.

LITERATURE REVIEW

In the literature, many methods and algorithms have been used for optimizing routing aspects of solid waste collection networks. Many papers have modeled the optimization problem of urban waste collection and transport as various versions of the Arc Routing Problem (ARP) [7], [8], [9]. Nevertheless, the particular problem has been also modeled as a Vehicle Routing Problem (VRP) in which a set of waste trucks have to serve a set of waste bins minimizing the cost function while being subject to a number of constraints. The characteristics of the vehicles and of the Genetic Algorithms for Municipal Solid Waste Collection and Routing Optimization 225 constraints determine the various types of VRPs [10], [11], [12]. However, the speed distributions, from which the travel times can be calculated, are supposed to be known at the beginning of the optimization.

In addition, the routing problem of the solid waste collection process has been treated as a Traveling Salesman Problem (TSP), which can be formulated as finding the minimum of a function representing the route that visits all the nodes of a set, at least once.

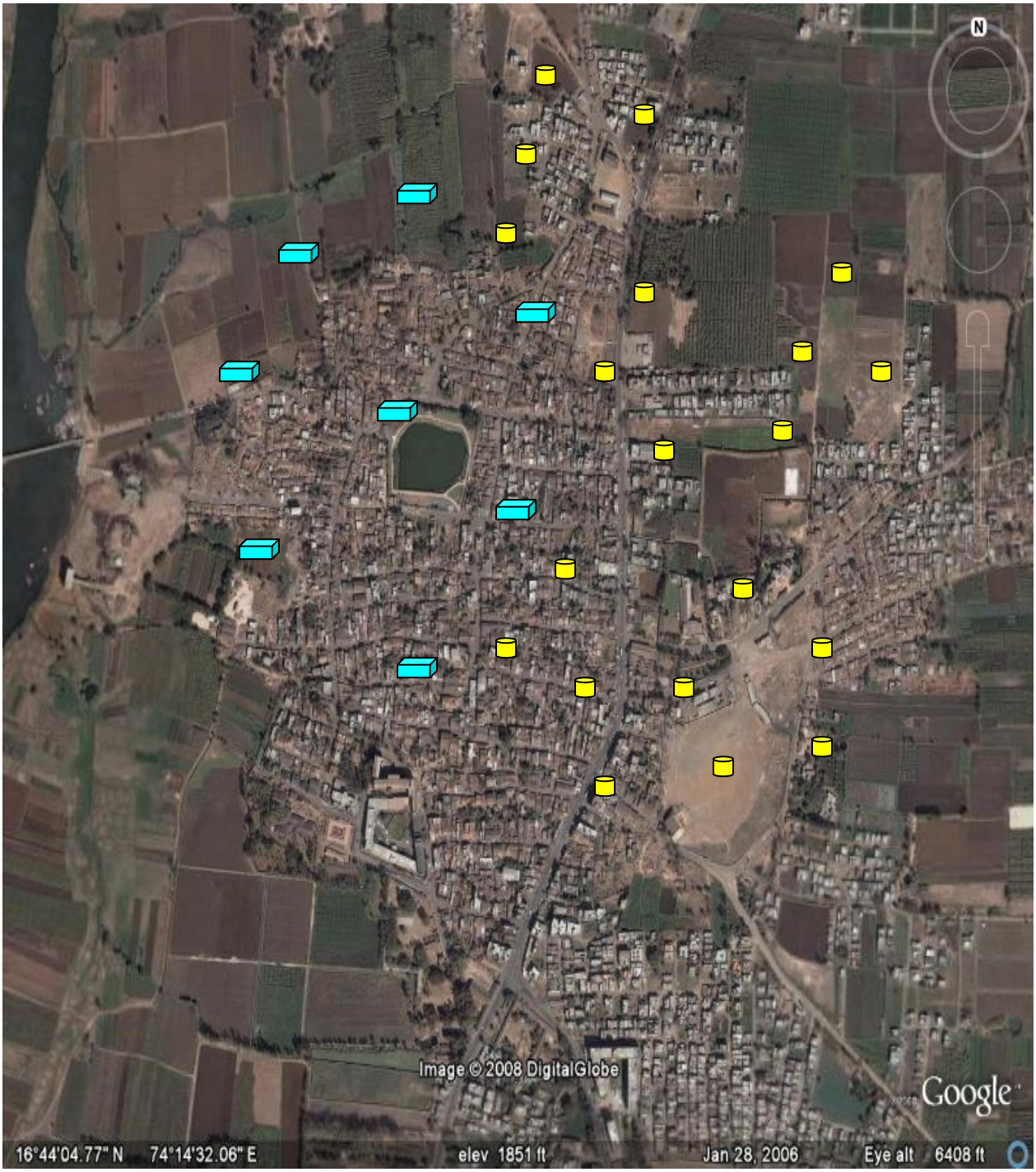
An Ant Colony System (ACS), a distributed algorithm inspired by the observation of real colonies of ants, has been presented [13], [14], for the solution of TSP and ATSP problems [15], [16]. Viotti et al. [17] introduce a Genetic Algorithm for solving the TSP and present its results. Poser and Awad [18] have developed a methodology based on real genetic algorithm for effectively solving the TSP in the field of solid waste routing system in the large cities.

In this context the problem is reduced to a Single Vehicle Origin Round trip Routing which is similar to the common Traveling Salesman Problem (TSP). The well-known combinatorial optimization problem, in which each waste truck, in this work, is required to minimize the total distance traveled to visit, only once, all the waste bins in its visiting list. In the traditional TSP, the cost of traveling (distance) between two waste bins does not depend on the direction of travel. Hence, the cost (distance) matrix representing the parameters of the problem is symmetric. However, the problem, which this work refers to, is modeled as an Asymmetric TSP (ATSP) problem due to road network restrictions. An ATSP problem considers that the bidirectional distances between a pair of waste bins are not necessarily identical. The ATSP problem can be solved to optimality using various algorithms. Some heuristic procedures for solving the symmetric version of the problem (TSP) can be easily modified for the asymmetric versions, but others are not.

The objective of this paper is the application of a optimization that is minimal spanning tree for the identification of optimal routes in the case of Municipal Solid Waste (MSW) collection.

IMAGE SHOWING STUDY AREA AND LOCATIONS OF DUSTBINS

FIG.1



CASE STUDY

In this research work, a small part of Kolhapur city was chosen as the case study area. The Corporation of Kolhapur has divided its area in about 11 sanitary wards solid waste collecting programs, where in general each one includes approximately 100 waste bins. Any garbage truck that is responsible for the collection of the solid waste in that given area must visit all the bins in order to complete its collection program.

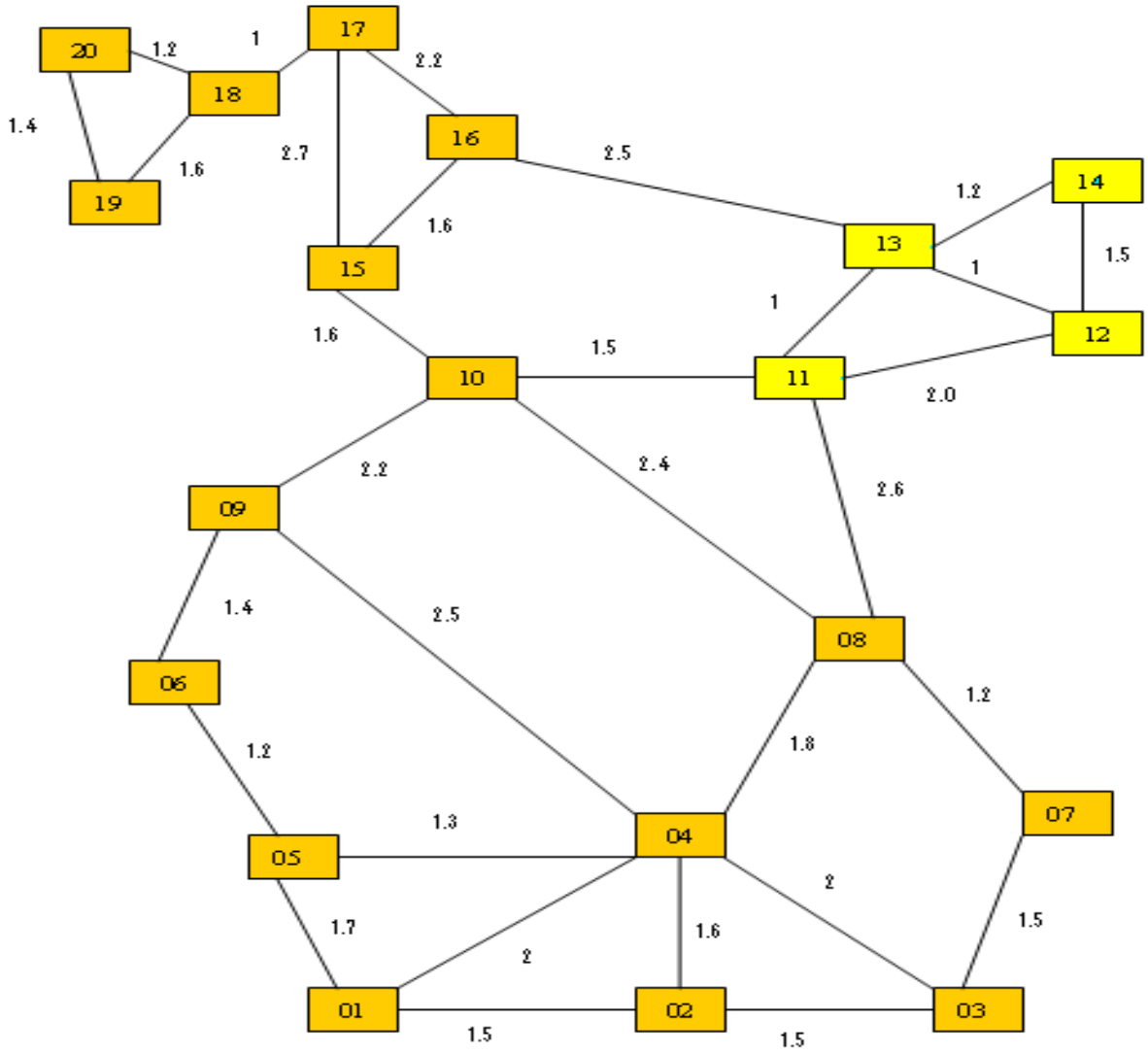
Population of this area is over 15,000 citizens and a production of about 3.5 tones of solid urban waste per day. The data concerning the area under examination was obtained from the Municipal authority. This data includes (address and numbering labels of streets), the building blocks and the locations of the existing waste bins. The waste bins locations were initially derived from a pilot program that the Kolhapur municipal authority was using for the allocation of their trucks.

Above image Fig.1 shows the proposed locations of dustbins at kasaba bawada area, as this area of Kolhapur city initially was a village and that's why its development is totally uneven, unplanned. The roads are so narrow, complicated alleys due to this it is very difficult to use community bin type collection system there. Now instead of that it will be better to use combination of community bin type and house to house collection system. The yellow spots in above image are circular dustbins (20 Nos.) for community bin type collection system. And blue colored squares are steel containers (8 Nos.) used as storage places for house to house collection.

In kasaba Bawada area the construction of houses is unplanned so creates problems regarding approach to collection vehicles, from these alleys the solid waste must be collected manually & thrown to near by dustbins but such kind of work is not done. Instead of that they collect the solid waste dumped at such places twice a week creating heaps & health problems to the people residing in surrounding areas.

If we see the flow chart in Fig.2 shows locations of the dustbins with distances between them. The distances are in (meter/100).

FIG.2

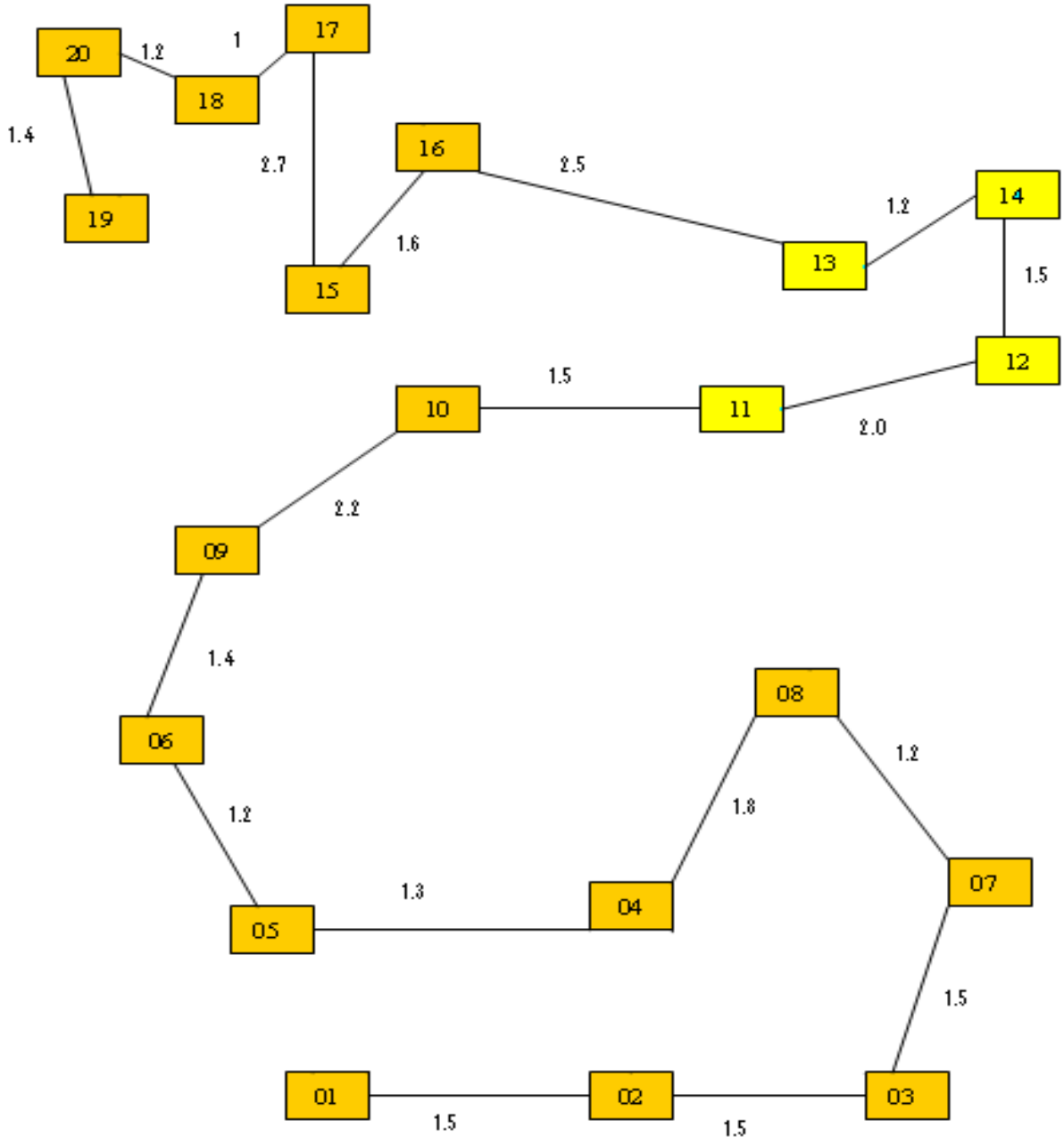


IMPLEMENTATION OF MINIMAL SPANNING TREE PROBLEM

Finding the minimum spanning tree is, in itself, an important problem. Building a network of roads to connect n cities so that the total length of the road is a minimum is a minimum spanning tree problem. Similar problems include television and telephone cable laying, pipeline layout, and finding minimum distance to school bus.

If you implement the minimal spanning tree solution to design collection system in above flow charts. We will get following shortest path covering all the dustbins with minimum possible distance as shown in Fig 3. Where dustbins 11,12,13,14 are kept out of loop to get proper answer. After that it is been introduced in to the solution.

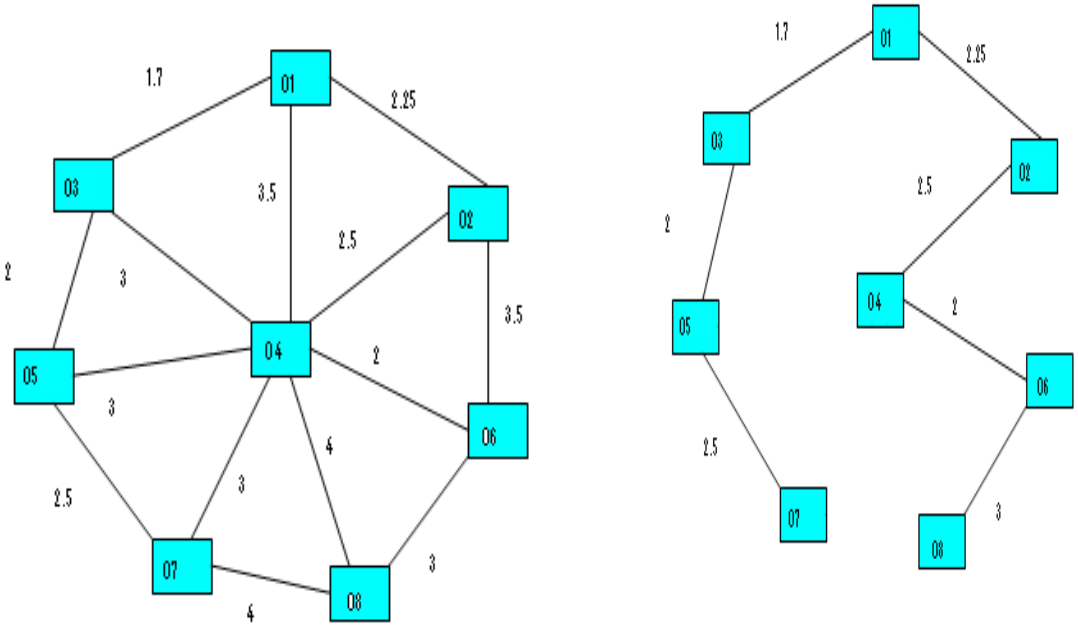
FIG.3



Total length covered is 3 km.

Similarly if we see the locations of square dustbins where house to house collection is proposed we will get following solution in Fig 4.

FIG.4



Total distance covered is 1.6 km.

If we implement this practically, at first where the cumulative dustbin collection system is to be implemented the total distance covered by the collection vehicle is 3 kms. If we consider we are collecting waste three times in a week following comparison we can make.

Initially conventional collection system includes near about 35 numbers of dustbins for the study area , only community bin type collection system is being used in this part of the city. This area comes under E-4 sanitary ward they are using 4 vehicles for collecting the waste, as we are studying only a part of it we can consider that they are using only 2 vehicles for this section and collecting twice a week. For E-4 ward 125 numbers of dustbins are provided and 135 sweepers. Even though the heaps generated in this area at 172 places most of them are situated in the study area which we have selected due to faulty locations of dustbins and problems of approach of vehicles to the located dustbins and heaps. This present scenario will tell us the money spend on collection here is totally wasted and authorities are pretending as everything is in control. As per the present budget requirement for solid waste collection the per capita cost for wate collection at

E-4 ward is 143/- Rs. and for the same for whole Kolhapur city is 161/- Rs. which is considerable where work is not done properly due to lack of planning.

This problem of solid waste collection not only at E-4 ward but also faced in other surrounding areas of Kolhapur city. For the same it is important to plan a proper collection system for this kind of unevenly developed places where, alleys are too small for collection vehicles and proper dustbin locations can not be selected. For that it will be effective if we use combination of two types of collection methods, that is house to house where alleys are too small and community bin type by increasing number of dustbins to tackle the heap generation problem. In Fig.1 yellow dots are for circular dustbins where community bin type collection is proposed and blue dots are for rectangular containers for house to hose collection having more waste holding capacity than circular dustbins. Locations of circular and rectangular dustbins are selected by studying the generation of waste and area where people can throw their waste with minimum possible approach distance.

Also the number of sweepers required as per the population is proposed to alter a little bit, that where house to house collection is proposed number of sweepers are increased by which they can collect the waste from house to house daily and throw it in rectangular containers and as the collection frequency is proposed three times a week at both systems the number of sweepers required in community bin type collection system is less. And as per the locations and collection schedule it is possible to collect 100% waste generated. Possibility of heaps generation is very less. Due to optimizing the routes as per the proposed location it is possible to collect the solid waste from all the dustbins with minimum traveling distance and time as well. By that it is possible to collect all the waste generated within available resources and with very less expenses. The per capita collection charges can be reduced in this area up to 135/- Rs. As we know that as a whole it will save considerable amount, and problems regarding waste collection is minimized.

CONCLUSIONS

This work focuses on the collection and transport of solid waste from waste bins in the area under study. The minimal spanning tree is introduced and implemented, for monitoring, simulation, testing, and route optimization of alternative scenarios for a solid waste management system. The first experiments have shown that applying the optimization technique for the solution of this every day problem – the collection of urban solid waste – can greatly minimize the collection tour length and eventually the total cost in time and money. However, as it was reported above, the particular problem is much more complicated than presented in the current work. The proposed methodology was applied in a region of the Kolhapur city which contains a quantity of solid waste generation equal to the capacity of the waste truck used in this particular area. Although the case study covers an some area of Kolhapur having about 15,000 citizens. Such problem of uneven growth and generation of heaps is common in surrounding areas of city. This method ensures the reliability of the results, a future prospect of this work is that the proposed method of collection can be implemented at places where collection problem is severe.

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