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Collection of Municipal Solid Waste for a city by using CPM

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Abstract :*Solid waste management has become a major problem in our country. Due to industrialization and urbanization the generation of solid waste is growing day by day. However, the most difficult and main component of MSW is proper collection of solid waste. If it is not designed properly, then it has its worst impact on labour operational and transport cost and has the negative effect on environment. Almost 70% of total MSW management cost is spent on the collection and transportation of the solid waste. Hence the slight improvement in the collection method can result into the significant saving of overall cost. After carrying out detail study about the waste management in the city, we found that the waste is not being collected totally from the areas and also they required near about 6 hours to collect waste from each section. Hence to improve the current scenario we study the road maps, quantity of waste generation, collection methods, etc. Then with the application of Critical Path Method (CPM) we have find the shortest path for the collection of waste, and after carrying out further calculation, we get the final result that, by following this shortest path for the collection, the vehicle can collect maximum amount of waste within 3 hours only, which has reduced the overall collection time as well as cost required for the transportation.*
***Keywords** : Municipal solid waste management (MSW), CPM*

I. Introduction

Solid waste management is a worldwide phenomenon. Improper management of solid waste causes hazards to inhabitants. It has a become a big challenge in our country too. This problem is also prevailing in our Wardha city, which is creating a threat to environment. If it is not done properly it will leads to serve environmental problems in the city.Solid waste management is defined as the management carried out to control the generation, storage, collection, transportation and at last proper disposal of the solid waste in the city. Generally solid waste contains household waste, commercial waste, industrial waste, clinical as well as electronic waste.Solid waste management can be divided into key components : 1. Generation, 2. Storage, 3. Collection, 4. Transportation

1.1 Current MSW Management Scenario of the city :

Wardha is now an important centre for the trade. Day by day, the city is entering into the process of urbanization which has arouses the severe problem in the provision of potable water supply, clean air and waste disposal. Hence it is important to recognize the impact which urbanization has on environment as well as to the community of the city. One of the important impact is the solid waste. There has been a significant increase in MSW generation in Wardha in last decade. This is largely because of rapid population growth and infrastructural development. Municipal solid waste generation in Wardha has increased from 2-3 tons/day to 30 tons/day in last 10 years. Hence it requires a proper management system.

1.3Critical Path Method :

At many places this methods are improved by developing softwares based on IoT algorithms, mathematic the collecting path. Critical Path Method is developed in the year 1950 by Morgan Walker. In this method, a network flow is formed by considering the events & activity. It is activity oriented method. The duration required to complete an event is known as activity. By analysing the time period required to complete an event, we can find the critical path to complete various activity included in the network flow within a minimum duration. We can estimate the time period required to complete the various activities in any type of work with the help of critical path method.

II. Methodology :

2.1. Study Area :

Wardha city is located near the Central City of India, i.e, Nagpur. It is governed by a municipal council. The city get its name from the Wardha river which flows at North, West and South boundaries of district. The total area of the city is 70 sq.km.

Fig 1 : Map of Wardha City

2.2. Population & MSW generation :

In 2011, Wardha had a population of 1,03,898. The city is divided into 5 zones according to the population as well as the inclusion of residential area, commercial area, industrial area into the zones. And all the 5 zones are again divided into 19 sections.

Sr.No	Zone	Population	Quantity of waste generation (kg)
1	I	29706	11882.2
2	II	27893	11157.2
3	III	14763	5905.2
4	IV	12072	4828.8
5	V	19464	7785.6

Table No.1 : Population & Quantity of waste

2.3 Study of current MSW collection system:

The detailed study of a current MSW collection system which is adopted by the Municipality is carried out. We studied the path or route adopted by the collecting vehicle to collect the waste from the city and transport it to the disposal site which is located in Inzapur which is 4.4kms away from the city. Municipality adopts the Door to door system for collecting the waste, which is the efficient way of collecting the waste in the city. As well as the community bins are provided in every sections within proper distance.

2.4. Data Collection :

In this phase, various data related to generation of solid waste, time required for collection and transportation of waste, no. of collecting vehicles, route maps of the city.

Description	Nos.	Capacity
Collecting Vehicle	10	800 kg
Tractors	4	1000 kg
Labours	247	-
Drivers	10	-
Containers	70	1500 kg
Road side dustbins	40	35 kg

Table 2 : Data related to current MSW system

2.5. Survey :

We formed a questionnaire to get details from the peoples about the current MSW system adopted by the Municipality. From this survey, we obtain details about the schedule of collecting vehicles, pre-installed

community bins in the areas and the problems faced by the peoples related to solid waste management in the city.

2.6. Propose suitable route for collection:

After the survey , we get details about the areas, generation of waste from particular zones. The city is divided into 5 zones which were further divided into 19 sections. Then studying those all sections on the map, we get the idea of how we can form a network of routes which will be followed by the waste collecting vehicle. Hence, we formed a suitable network of routes in each of the sections. Then by considering each section, a network is formed and from that we determined the entry and exit point from which the collecting vehicle can enter and come out from that particular section.

Fig2 : Route map of section-1

Table No.3 : Route followed by the vehicle

SR. NO.	WAY / ROUTE	TIME
1	Arvinaka to Dnyaneshwar temple	7.30 to 7.36
2	Dnyaneshwar temple to Tekdi temple	7.40 to 7.49
3	Tekdi temple to Ganesh temple	7.50 to 7.58
4	Ganesh temple to Maratha hotel	8.00 to 8.10
5	Maratha hotel to Durga complex	8.12 to 8.20
6	Durga complex to House 1	8.22 to 8.28
7	House 1 to Sarkari shop	8.30 to 8.39
8	Sarkari shop to House 2	8.40 to 8.48
9	House 2 to Syrus computer	8.50 to 9.00
10	Syrus computer to House 3	9.2 to 9.10
11	House 3 to Jagtap	9.12 to 9.25
12	Jagtap to Primary school	9.30 to 9.44
13	Primary school to Vaishnavi complex	9.45 to 9.57
14	Vaishnavi complex to JSM	10 to 10.12
15	JSM to Swastik medical	10.15 to 10.22
16	Swastik medical to Sparsh corner	10.25 to 10.35

Likewise, similar route is formed in all the sections. This routes are designed to be followed by the vehiclw which went to house to house and collects the waste and transport directly to the disposal site, i.e. the small waste collecting vehicle. For example, the waste collecting vehicle enters into the section from Arvi Naka at 7.30 a.m., which has become the entry point for the section 1. Then by following the as described in the table, the vehicle will came out from sparsh corner, which has became the exit point for the section 1. Likewise we get the similar entry & exit points for remaining sections. Considering those points we formed a network which are connecting various sections with each other.

2.7.**Application of Critical Path Method :**

After determination of the network, we get the entry & exit points, which is considered as the event and the path followed by the vehicle upto these points are considered to be as activity.Now, we get the set of events and activity, from which we have determined the shortest possible path with the help of CPM calculations.

2.7.1. Calculation of CPM network :

For calculation purpose, the total 19 sections are grouped into 4 zones. As we predetermined the entry and the exit points in the section, they are considered here to form a network flow throughout the 4 zones.

Calculation for Zone 1 :

Here, in network no. 1, the events which are numbered as 1, 3, 9A, 9B, etc. are the exit points of the section 1, 3, 9A, 9B respectively. We plot this points on the map and form the network as shown in the fig 3. After formation of the network, we determine the time taken by the truck to cover up the whole network. Then by using CPM calculations we get the shortest path in the network which must be followed by the truck.

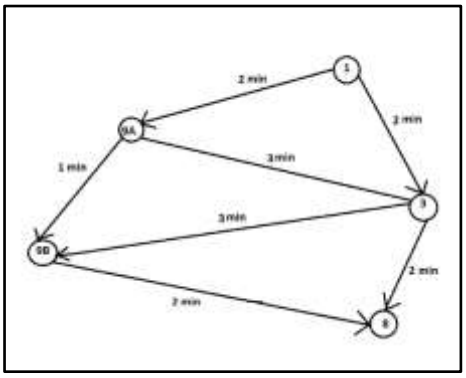

Fig 3 : Network of zone 1

SR. NO.	ACTIV-ITY	DURAT-ION	EST	EFT	LST	LFT	TF
1	1-3	2	0	2	7	9	7
2	1-9A	2	0	2	10	12	10
3	9A-9B	1	5	6	12	13	7
4	9B-8	2	6	8	13	15	7
5	3-9A	3	2	5	9	12	7
6	3-9B	3	2	5	10	13	8
7	3-8	2	2	4	13	15	11

Table No 4 : CPM calculation for zone 1

- **<u>Shortest path found : 1-3-9A-9B-8</u>**

Calculation for zone 2 :

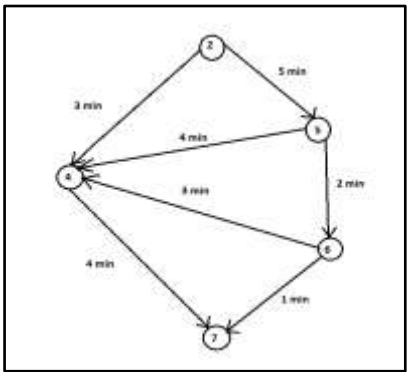

Fig 4 : Network of zone 2

SR. NO.	ACTIVITY	DURATION	EST	EFT	LST	LFT	TF
1	15-16	7	0	7	8	15	8
2	15-17	5	0	5	14	19	14
3	15-19	8	0	8	22	30	22
4	16-17	4	7	11	15	19	8
5	16-18	8	7	15	19	27	12
6	17-18	8	11	19	19	27	8
7	18-19	3	19	22	27	30	8

Table 5 : CPM calculation for zone 2

- **Shortest path found :**2 - 4 – 5 – 6 -7

Calculation for zone 3 :

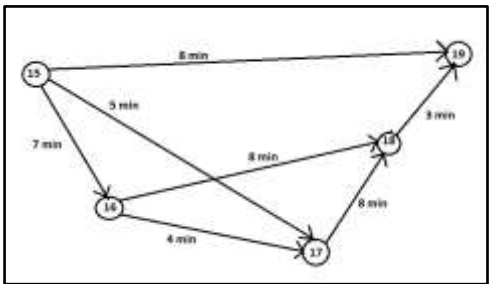

Fig 5 : Network of zone 3

SR. NO.	ACTIVITY	DURATION	EST	EFT	LST	LFT	TF
1	2-5	5	0	5	6	11	6
2	2-4	3	0	3	13	16	13
3	5-4	4	5	9	12	16	7
4	5-6	2	5	7	11	13	6
5	6-4	3	7	10	13	16	6
6	6-7	1	7	8	19	20	12
7	4-7	4	10	14	16	20	6

Table No 6: CPM calculation for zone 3

- **Shortest path found :**15 – 16 – 17 – 18 – 19

Calculation for zone 4 :

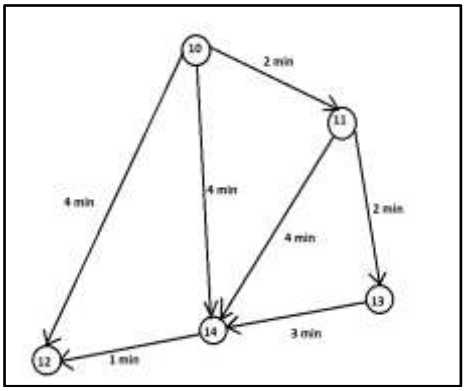

Fig 6 : Network of zone 4

SR. NO.	ACTIVITY	DURATION	EST	EFT	LST	LFT	TF
1	10-11	2	0	2	7	9	7
2	10-14	4	0	4	10	14	10
3	10-12	4	0	4	11	15	11
4	11-13	2	2	4	9	11	7
5	13-14	3	4	7	11	14	7
6	14-12	1	7	8	14	15	7
7	11-14	4	2	6	10	14	8

Table 7 : CPM calculation for zone 4

- **Shortest path found :**10 -11 – 13 – 14 – 12

After finding the critical paths for all the 4 zones we get a complete network of route which covers the total area of the Wardha city which is shown in the map below.

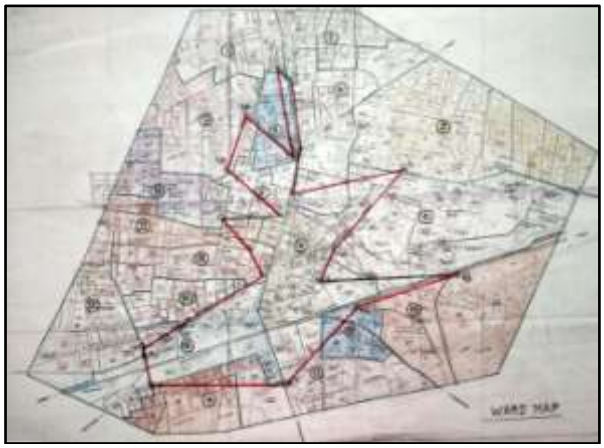

Fig 7 : Shortest route to be followed

The small waste collecting vehicle will collect the waste from the alloted section only and after filling the container at its full capacity will go to the exit point of the section where all the waste is emptied in the truck or tipper. Similarly the truck will visit to every exit point travelling through the route which is determined by CPM. After collecting waste from each zone, the truck will move to the disposal site.

III. Conclusion :

We studied the current MSW system adopted by the Municipality of Wardha. We found that they are using small vehicles for collecting as well as for transporting the waste to the disposal site which is located 4.4 kms away from the city at Inzapur. In this ongoing process they required near about 6 hours to collect the waste and half an hour to transfer it to disposal site. But after providing separate truck for transferring the waste to disposal site by following the route shown in the fig 7, the overall time required to the collection and transferring process is reduced to 3 hours. Along with that fuel consumption is also be reduced. That means the 60-70% cost required for the transportation of waste is gradually decrease to 40-50% which can make the solid waste management system more economic and more efficient.

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