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RESEARCH ARTICLE

GIS APPLICATION FOR SUITABLE LOCATION OF WASTE BIN FOR SOLID WASTE MANAGEMENT IN KHULNA CITY

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ABSTRACT

In Khulna city the municipal work force disposes hardly daily waste about 520 ton/day (per capita production of solid waste is 0.5kg/day). Khulna city is consists 31 wards where ward no 18, 19 and 20 are mostly commercial and residential area comprises 2.81 km^2, which is the mostly dense populated and low profile municipal solid waste (MSW) safe management in Khulna city corporation (KCC). The study reveals that total number of population of those wards are 63078 and disposed 31539 Kg MSWper day but total amount of collection capacity 21000 Kg, so 10539 Kg waste disposed illegally in different place like drain, pond, field, road side as well as open place. Suitable disposal location of waste bin must have environmental safety criteria and identified usable place where there is no unacceptable risk to environment or to people. Criteria for suitable waste bin location include natural physical characteristics and mental characteristics for user as well as socioeconomic, ecological, land use factors, user travel time, concern about public institute, easily access and publicly concern about environment road width. Different tools and techniques are being developed for MSW disposal site selection in developed countries. The Geographical Information System (GIS) is a new technique which can offer an opportunity to integrate field parameters with population and other relevant data or other associated features selection of suitable waste bin location.

Keyword: GIS, solid waste, waste bin, served-unserved area, Khulna.

INTRODUCTION

Solid Waste Management (SWM) is a function of combination of various activities such as collection, transportation and disposal of solid waste. It also includes processing and treatment of the solid waste before disposing[1].The purpose of SWM is to create uncontaminated environment for people without disturbing natural resources [2].Solid waste is non-liquid waste materials arising from domestic, trade, commercial, agricultural, industrial activities and from public services [3].Urban solid waste management (USWM) is

considered the most important concern and complex issue all developing due to population, urbanization and affluence.The most common problems arises with improper management of solid waste including diseases transmission, fire hazards, odor nuisance, atmospheric and water pollution, air pollution, aesthetic nuisance and economic losses. So all over the world it is globally concern to safe environment from pollution and different method are used to collect, transport and disposal. Solid waste management has improved with helps of ideas and new technology in world.

Netherland government has implemented high land filling tax to make it less interest by the people and incineration of waste is the favored method of waste treatment to reduce environmental risk [4].The most popular method of waste disposal in Canadian urban centers is curbside collection. But in rural areas people have to carry their waste to the transfer stations. Then waste from this transfer station is transported to landfill site [5].In Australia urban households have been given a bin to put their waste and those bins are emptied weekly by the local council [5].Basic measures taken in recent years to control waste management in Japan include: pollution prevention, reuse and recycling, and waste incineration with air pollution control [6].Similarly in many Indian cities and towns, solid waste is normally disposed in an open dump[7]. In developed countries seeking to reduce waste generation, a current goal is to decouple waste generation from economic driving forces such as GDP[8].Bangladesh is a developing country and experiencing the problems of solid waste management.At present, 522 urban centers including 254 municipalities in 7 cities are present in Bangladesh [9]. In Bangladesh, solid waste disposal and management system are very low profile because urban areas generate huge amount of solid waste which overflow solid waste management facilities. Only major cities have some facilities of solid waste management.In the major cities in Bangladesh, per capita production of solid waste 0.5 kg /day but only 0.2 kg of waste per capita is carried to the final disposal[10].This view of the major cities of any country obviously exhibits the poor waste management situation of that country. The estimates of solid waste generated in Khulna cities is 520 ton/day but waste carried KCC to the final disposal 300 ton/day, so 220 ton waste dump illegally per day in Khulna city[11].This situation is more alarming to the environment. Improper management and lack awareness are the main reasons for the environmental pollution. The main aim of the study is to reduce illegal dumping waste by application GIS. GIS can provide a planning opportunity of waste bin location selecting in some part of Khulna city.

STUDY AREA

Khulna, the third largest metropolitan city of Bangladesh, stands on the banks of the Rupsha and the Bhairab rivers. It is in the south-western part of the country with its location on the axis of Jessore-Mongla port, the second largest seaport of the country. Geographically, Khulna lies between $22^0$47´16´´to $22^0$52´ north latitude and $89^0$31´36´´to$89^0$34´35´´east longitude. The city is 4 meter above the mean sea level (MSL). At present, Khulna city has a population of about 1.4 million with an area of 45.65 square kilometers and 31 Wards shown in Table 1. The study areas are ward no 18, 19 and 20 shown in Figure1 which is the most densely populated and low profile solid waste managementcomprises 2.81 km^2. The amount of population of those wards is 63078 and number of household is 14104[12].

Table 1: Population and household data

Ward no	Area(km^2)	Population	Household
18	1.74	27896	6065
19	0.54	18558	4350
20	0.53	16624	3689
Total	2.81	63078	14104

The study area are mostly commercial and residential area comprises 2.81 km^2 with 14104 household, the total amount of population is 63078and waste generation in this area is 31539 kg per day (per capita production of solid waste is 0.5kg/day) .There are 18 waste bin 16 are concrete (2 m^3) and 2 is haul container (5m^3) which carrying capacity is 21000 kg (concrete bin is 1000 kg and haul container is 2500 kg)[13] and10539 kg waste illegally dumping different place like drain, pond, field, road side as well as open place which is arising hazardous problem shown in Table 2.Moreover, thepresent scenarios of common types of waste bin such as concrete bin (Figure 2) and haul container system (Figure 3) in Khulna city and some scenarios on Illegal dumping location of study area shown in Figure 4.

METHODOLOGY ADOPTED

The prime objectives of the study are given below:-

1. To investigate the solid waste management system (SWM) in study area.
2. To investigate the waste bin capacity and type.

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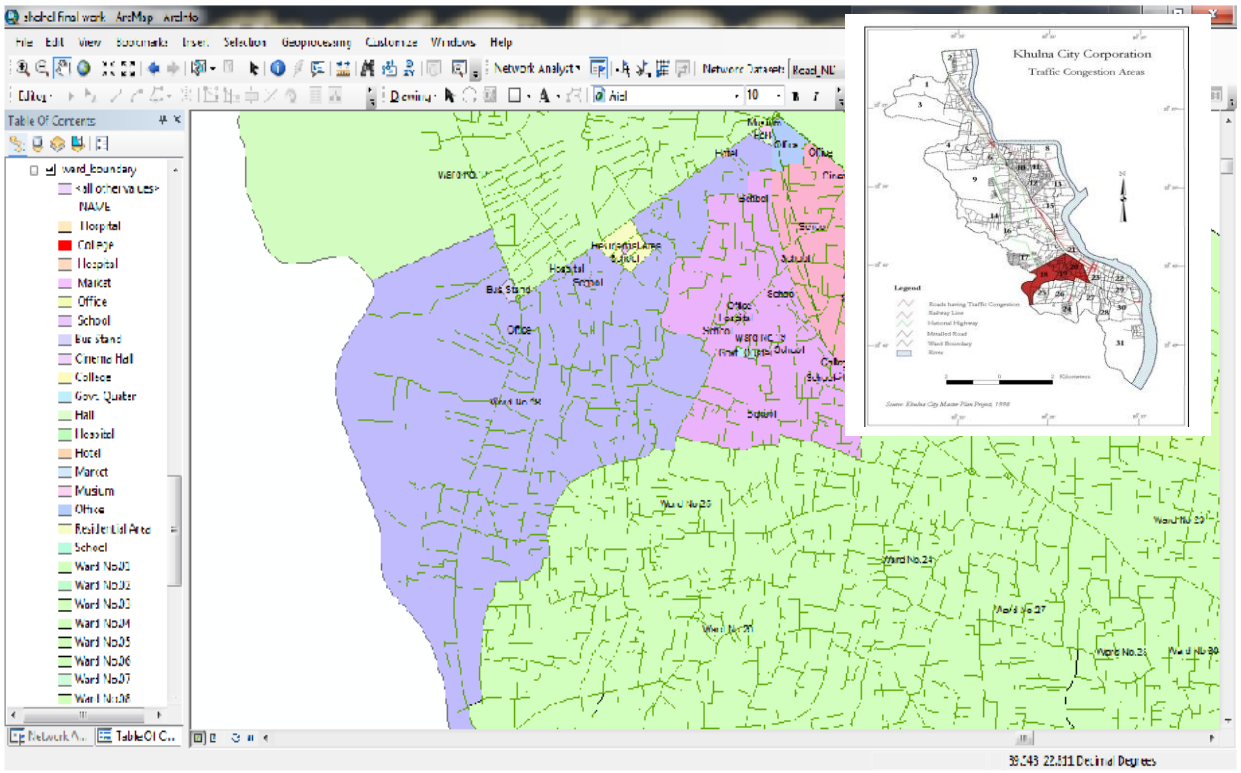

Figure 1: Study area map in Khulna city

Figure 2: Present scenarios of concrete bin

Figure 3: present scenarios of haul container

Figure 4: illegal dumping location.

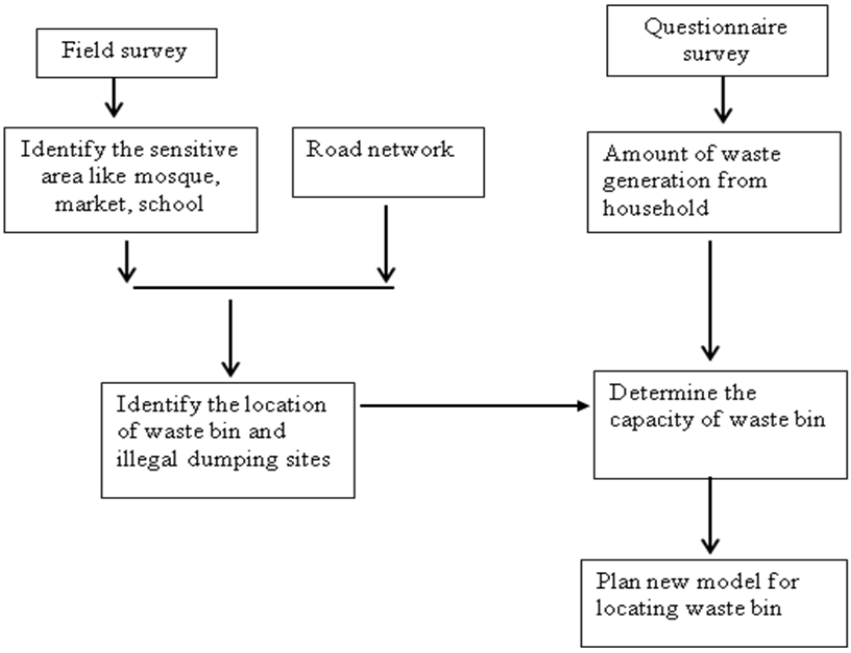

Figure 5: Procedure of the study on the basis of survey

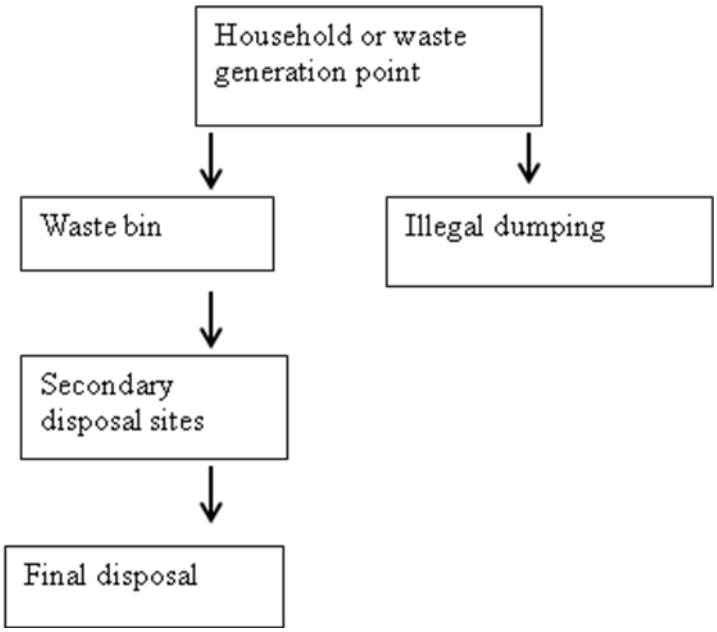

Figure 6: Waste generation point to final disposal

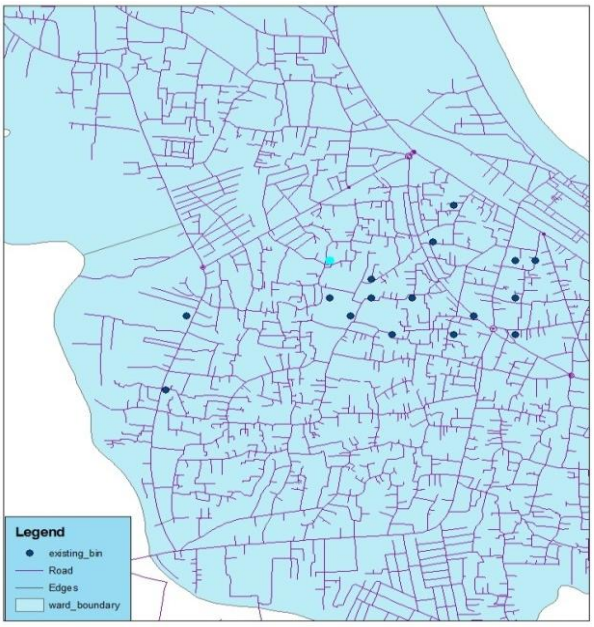

Figure 7: Existing waste bin location in study area

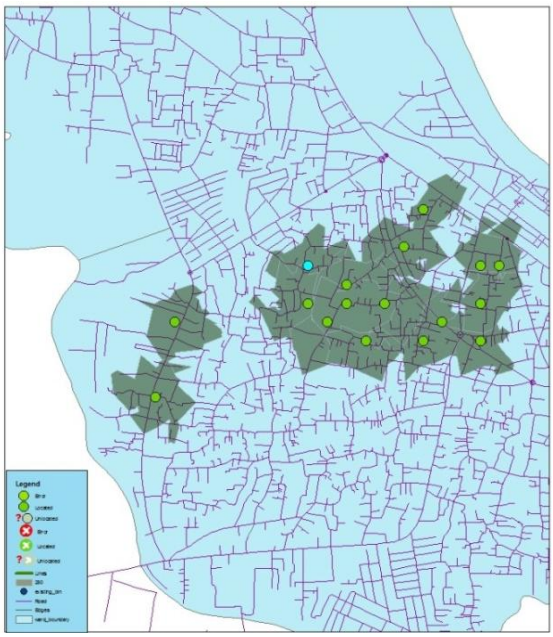

Figure 8: Existing waste bin service area at 250 m

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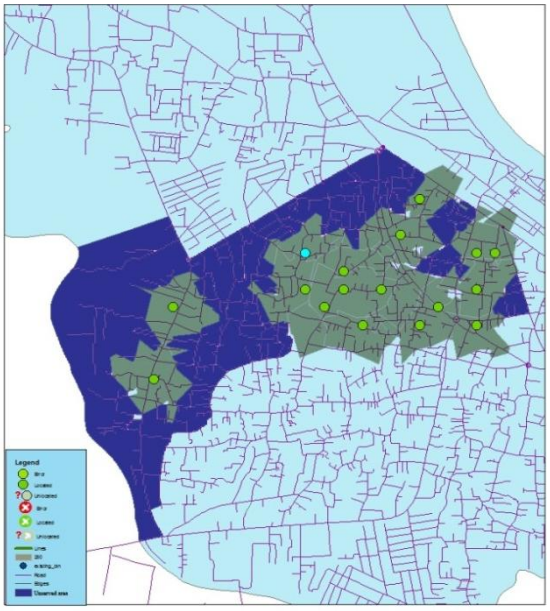

Figure 9: Existing unserved area

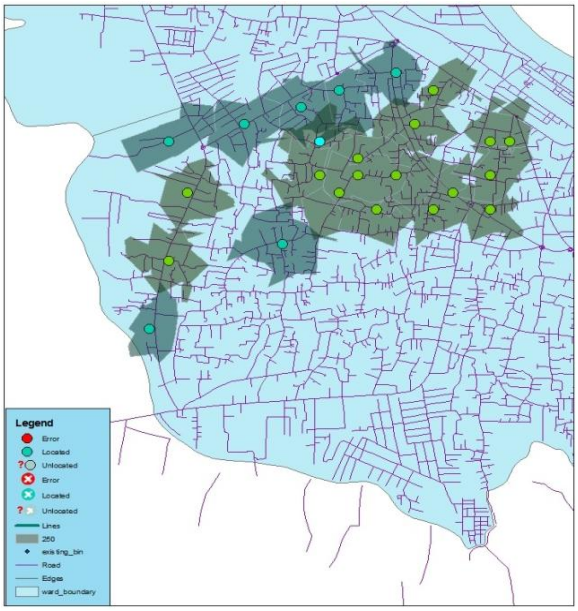

Figure 10: Selecting optimum location of waste bin at 250m service area

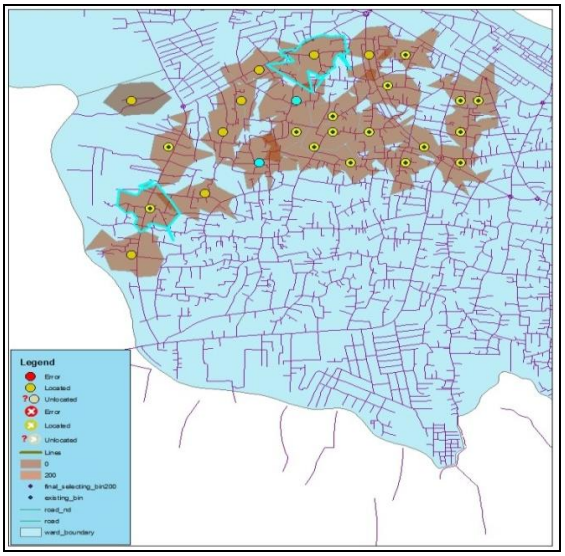

Figure 11: Selecting optimum location of waste bin at 200m service area

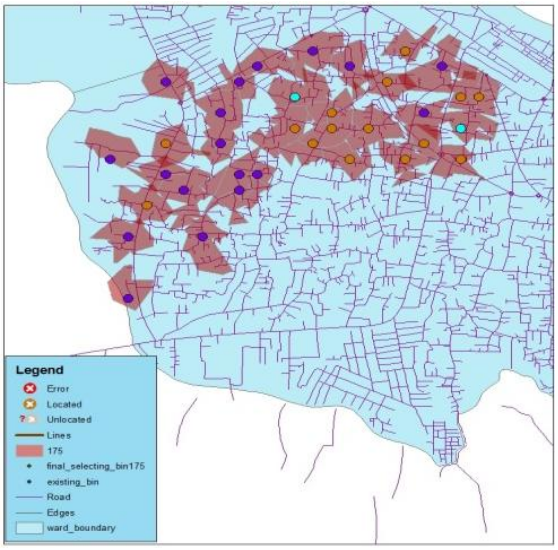

Figure 12: Selecting optimum location of waste bin at 175m service area

3. To investigate illegal dumping waste disposal and to identify the environmental problem generated due to illegal dumping.
4. To determine the serve and unserved area by GIS
5. To provide suitable location of waste bin using GIS.

Table 2: Waste bin condition

Type of waste bin	No of waste bin	Volume of bin ($m^{3)}$	Per volume capacity(kg)	Amount of waste(kg)
Concrete bin	16	2	500	16000
Haul container	2	5	500	5000
		Total		21000

Methodology is a systematic part of the study to guide scientific investigation. It is a common technique in which various data collection and information are explained. Primary data were collected to propose options for better solid waste management on study area. Random questionnaire survey was conducted at the study area with collecting Geographic Position System (GPS) of existing waste bins, containers, mosque, school, college, market, hospital and illegal disposal sites using GPS device (Explorist 200). With the help of ArcGIS Network Analyst tolls selecting the location of waste bin. Find out the service area of waste bin by Network Analyst tool on GIS. To determine the waste serve areas of waste bin with its capacity and unserved area. To propose a new plan to cover maximum area waste with a suitable location. Selection of new waste bin location to reduce illegally dumping waste in the study area. Procedure of the study on the basis of survey provided in Figure 5 and the waste generation point to final disposal is shown in Figure 6.

MODEL ANALYSIS

Model is developed on GIS for selecting suitable location of waste bin in study area. GIS analysis is help to show proposed location of waste bin can serve approximately total study area and user can find waste bin maximum preferable walking distance. Developing model has been used some considerations, there are:

Firstly, all contexts are included to the study area like as population, road network, density, household waste generation, socio-economic condition and existing solid waste management consideration of study area.

Secondly, the study areas people are used waste bin which are situated in the study area.

Thirdly, equal waste bin size and capacity like as concrete bin capacity is 1000Kg and haul container capacity is 2500Kg.

Fourthly, per capita waste generation rate at 0.5 kg/day are considered.

Fifthly, inhabitants are open choice to disposal waste service household to waste bin and

Sixthly, inhabitants travel time consideration to find out waste bin. Low travel distance and maximum facilities are more preferable.

The existing condition of waste bin location of the study area is not sufficient to the inhabitants to dispose their waste in waste bin. Existing waste bin can serve lower area where maximum area are remain unserved that is the reasons new model of waste bin location are developed to serve the total study area with minimum installation cost. New waste bin installation is depends some criteria maintain. Firstly, from the field survey the possible location of waste bin is placed on the roadside. Waste bin is usually placed road side in Khulna city, so the municipal authorities likes to place waste bin with respect to road width. Wider road is prefers to place haul container and inner road is prefers to place concrete bin because of waste collection facilities. From the concrete waste are carried to the haul container and finally dumping landfill. Secondly, it will be concern that waste bin is not install where high traffic volume, junction and busy point because of avoiding disturb of locality. To proposed new model analysis coverage area with help of GIS network analyst tool.

ANALYSIS OF SERVICE COVERAGE OF EXISTING WASTE BIN

From field survey and questionnaire survey it was fully clear that the preferable distance of waste bin for the households is 150m to 250m. But the existing condition of waste bin is service poor coverage area which is not satisfied of the waste management fulfillment. There are 18 waste bin in the study area 16 are concrete bin and 2 are haul container which is not capable to cover 2.82 sq. Km area waste. Most of the areas are not served for this reasons illegally dumping is occurred. To solve this problem new waste bin is needed to provide

within a shortest travel time and coverage maximum area.

area and unserved area is shown in Figures 7-9. New waste bin is provided with respect of existing bin position and trying maximum unserved area to serve by new waste bin.

SELECTING OPTIMUM LOCATION OF WASTE BIN AT 250METER DISTANCE

Optimum location to250m means inhabitants can find out waste bin easily around 250m from their household. KCC solid waste management facility is not enough to coverage study area so it is needed to locate new waste bin. There are 8 new waste bin is located in the study area where 2 haul container and 6 concrete bin are setup. Two containers are placed at the peripheral road and other 6 are placed inner road of the study area where KCC vehicle can easily collect. Total collection capacity of those bins is now 32000kg which is theapproximate to the total waste. But it could be difficult to travel such a distance with carrying full bags of garbage. If a man causal walking speed 20min per 1kilometer, so inhabitants needs 10 minutes to throw waste and come back home. So that some peoples are not interested to use waste bin at 250m location from their house. For this reasons this model cannot fulfill their goal of waste safe management shown in Figure 10.

SELECTING OPTIMUM LOCATION OF WASTE BIN AT 200 METER DISTANCE

Optimum location to200m means inhabitants can find out waste bin easily around 200m from their household. Waste bin is set up 200m walking distance with the help of ArcGIS Network Analyst tools where 9 new waste bins is set up after check and trail, 3 are haul container and 6 are concrete bin showing in Figure11. 3 containers are placed at the peripheral road and other 6 are placed inner road of the study area where KCC vehicle can easily collect. Total collection capacity of waste of waste bin is 35500kg. Total waste can be collected in this modeling and total travel time of inhabitants needs 8 min to throw waste and come back home. Installation cost is not high than 250m distance location modeling. So this modeling is more preferable.

SELECTING OPTIMUM LOCATION OF WASTE BIN AT 175 M DISTANCE

Optimum location of 175m distance GIS analysis resulted for high number as 18 new waste bins is needed to locate in the study area. There is 1 haul container and 17 concrete bins are set up with respect to the existing waste bin showing in

Existing position of waste bin, existing bin possible service

Figure 12. This bin is more capable to carry study areas waste and travel time is 7 min to throw and come back home. But installation cost is very high in this modeling. Municipal authority cannot support this modeling to concern about socio-economic conditions.

RESULTS AND DISCUSSIONS

In developing country there three methods is used to waste disposal. There are burning, open dumping and put waste in to the vehicle. Burning and open dumping is creating pollution like as air pollution, water pollution, different diseases and environmental pollution. But the study area one method is used for waste safe management. From questionnaire surveypeople said that they are needed waste bin at the closest distance from their household. But KCC cannot take proper steps to locate new waste bin and everyday lots of waste are illegally dumping in the drain, road side and open place where KCC vehicle cannot go. So different insects likeflies, mosquitoes, cockroaches, rats are spreading diseases like Dengue, Malaria, Brain fever, Pylaria etc. damaging drainage system. There is needed to setup new waste bin in the study area along the road side so that people can find easily. Optimum location of waste bin around 200m distance from the household is selecting wise decision for solid waste management which are less travel time and installation cost. The capacity of the waste bin this model is coverage total collection of waste bin and location of waste bin is the optimum path to the KCC vehicle from haul container or secondary disposal sites to final disposal. ArcGIS optimizing route tools can find easily optimizing shortest path of final disposal.

CONCLUSION

Urban solid waste management is efficient concern about waste collection and 66.57% of waste collected by KCC with the existing bin and haul container. So problem arises when 33.41% waste are illegally dumping can causes various environmental problem and diseases. To improve this solid waste system new waste bin in 200 m optimizing distance is provided essential to collect 92% waste in the study area. This bin is found easily area inhabitants with short travel time. Waste location and Service area of a bin can be calculated accurately using Network Analysis function in GIS software

instead of creating polygon buffer around it and easily located waste bin road side. GIS technique is helpful not only minimize waste but also collect and minimizing cost by optimizing route.

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