

RESEARCH ARTICLE

SECONDARY DISPOSAL SITES FOR SOLID WASTE MANAGEMENT IN KHULNA CITY AND OPTIMIZING ROUTES FOR FINAL DISPOSAL USING GIS

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ABSTRACT

This study concentrates to investigate the present situation of secondary disposal site (SDSs) and to develop an optimized route plans for collection and disposal of municipal solid waste (MSW) from SDS to ultimate disposal site (UDS) using GIS. The present study reveals that there is no systematic time and route plan for the storage, collection and disposal of MSW from SDS to UDS. There are more than 40 SDSs are available from where Khulna City Corporation (KCC) vehicles are collected the MSW and approximately 26 Haul Containers (HCs) and 1200 community bins, located on roadsides throughout the city. To investigate the present situation of SDSs a questionnaire survey was conducted and the feedback was recorded. Moreover transportation facilities, types of vehicles were investigated and finally the coordinates of SDSs, KCC garage and UDS were recorded using mobile GPS. After collecting all the relevant information then analyzed using SPSS 17.0 and optimized route plans were developed in GIS using ArcGIS v.9.2. Therefore, an attempt is made to propose a sustainable plan through which the existing facilities are properly utilized by providing an appropriate route plans having minimum travel distance which contribute to cutting a large amount of MSW management cost.

Keywords: Solid waste, secondary disposal site, ultimate disposal, route optimize, GIS, Khulna.

INTRODUCTION

Khulna, the third largest metropolitan city of Bangladesh, is located in the southwestern part near the Sundarbans, the largest mangrove forest of the world [1, 2] shown in Figure 1. It is situated below the tropic of cancer, around intersection of latitude 22.49° north and longitude 89.34° east [3]. Total area of KCC is 47.0 sq. km. comprising 31 wards [4]. Surrounding districts are Satkhira at west, Bagerhat at east, Norial at north and Jessore at noth-west, and the Sundarbans, then the Bay of Bengal at its south. It lies along the Bhairab river. The city stands on the bank of Rupsha and has an important river port. It is connected by

river, road and rail to the major cities of the southern Gangetic delta. It is long-shaped a city extending from southeast to northeast along the Bhairab-Rupsha River. The spontaneous nature of city growth and its shape are greatly influenced by the rivers Bhairab-Rupsha and Khulna-Dhaka road.



MSW collections from generation sources in Khulna city are mainly done by Non-government organization (NGOs) and community based organization (CBOs) in KCC [5]. Door-todoor collection systems are adopted for MSW collection from generation sources and then dispose major portion of it to the nearest SDS. From there KCC vehicles collect the MSW and transport it to the UDS. Some NGOs transfer their collected organic wastes to composting plant. Whilst city authority has some limited numbers of non-motorized Rickshaw Vans and Hand trolley those are mainly used for the collection of MSW from community bins located at roadside, home side, near market and transfer to SDS. Besides this drain sludge's are also collected by this van. To

these attempts, to investigate the present situation of SDSs a questionnaire survey was conducted and the feedback was recorded. Moreover, transportation facilities, types of vehicles were investigated and finally the co-ordinates of SDSs, KCC garage and UDS were recorded using mobile GPS. Moreover, data from questionnaire survey were analyzed using SPSS 17.0 and optimized route plans were developed in GIS using ArcGIS v.9.2.



Figure 1: Location of Khulna city as studv area



Figure 2 Present scenarios of SDS (a) Mountable haul container and (b) Demountable haul



Figure 3 Present scenarios of SDS (a) Large covered metal container and (b) Brick masonry dustbin



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Figure 4 Results of SPSS analysis about SDS near your area



Figure 6 Results of SPSS analysis about dustbin within 500 meter.



Figure 8 Results of SPSS analysis about the present scenario of SDS





Figure 5 Results of SPSS analysis about collection media of generated MSW from household



Figure 7 SPSS analysis of collection prototype for MSW from SDS



Figure 9 Clean and collection prototype of MSW from SDS



Figure 11 Biggest problems around SDS



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Figure 12 How to improve the present situation of SDS

PRESENT SCENERIO OF MSW MANGEMENT IN KHULNA CITY

The city authority generally manages the MSW however; recently, some NGOs, CBOs and private organization are working for door-to-door collection with city authority's initiatives [2]. Door-to-door collection systems are introduced recently for MSW collection from generation sources, mainly from households, and then dispose major portion of it to the nearest SDS [1]. City authorities collect these MSW and transfer it to the UDS and they are facing very complicated situations for the management MSW. Due to severe financial constraints, lack of motivation, absence of effective legislation to protect the environment, lack of commitment of authority, the MSW has becoming a threat for city dwellers, planners and other concerned stakeholders [6]. The management tiers of MSW can be categorized and hence discussed in followings.

Primary Collection

A significant portion of population does not have access to MSW collection services and only a fraction are actually collected by door-to-door collection systems introduced by NGOs and CBOs in late 90's in Bangladesh for tiny payment. MSW are collected from generation sources by NGOs, CBOs and city authority by door-to-door collection systems, and most of the cases owner by himself disposes it to the nearest community bins/SDS/open land/road sides/drains [5], whilst city authority has some limited numbers of nonmotorized rickshaw vans and hand trolley those are mainly used for the collection of MSW from community bins and transfer to SDS.

On-site Storage

On-site storage is the SDS and transfer station which receives MSW from primary source and transfer to the designated location for processing/recycling/treatment and mostly for ultimate disposal [7] SDS is considered as the



Figure 13 Authority should collect MSW from SDS

facilities where large amount of MSW are accumulated and finally transferred to the desired sites by large vehicles such as open or closed trucks, demountable haul container truck, etc [8, 9]. The SDSs are located in the selected places based on population, space availability, accessibility and other local factors such as desire of influential city dwellers or public representatives [10]. The wide variety of types and shapes of community bins are built by the civic bodies and/or city authority, which are located on the roadsides at frequent intervals. MSW from community bins are transferred to SDS mostly by city authorities through nonmotorized Rickshaw van and hand trolley. The present scenarios of common types of SDS for MSW in Khulna city is shown in Figures 2-3.

Secondary collection and transportation

The functional element of collection includes not only the gathering of MSW and recyclable but also the transportation after collection, to the location where the collection vehicle is emptied [11]. Only respective city authority is responsible for collecting MSW from SDS and transported it by motorized vehicles/trucks and finally disposed in the designated UDS. Although NGOs and CBOs collect MSW from households/ generation points and dump it to the SDS, they do not take responsibility for the collection & transportation of MSW, which they deposited in the nearby SDS [5]. Conservancy department of KCC setup the time-schedule and types of vehicle for collection and transportation of MSW. Generally, collection vehicles such as dump truck, normal truck, open truck, tractor with trolley, tipping truck (container carrier), de-sledging vacuum tanker with tractor, power tiller with trolley stands in the road nearest to the SDS for operation. Typical collection methods from SDS and MSW heaped transport vehicles.



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Morning Morning

🖬 Afternoon

Noon

Night 🖬

Authority should collect waste from SDS at

43%

Figure 15 Authority should collect MSW from

11%

16%

30%

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Figure 16 Feedback from people about MSW practices

METHODOLOGY ADOPTED

Field Investigations and Questionnaire Survey

A direct observation and survey have been conducted among the local people, local leaders and related organizations with a pre coded questionnaire survey. Study on the local people about their perception and feedback to SWM system at SDSs and the way other people respond to it. In case of sample selection this survey was conducted with the decision to choose at 31 SDSs of Khulna city giving priority to the affected communities. Due to limitation of time and fund, it was not possible to survey the whole of the Khulna city. Instead of taking into consideration the entire households within the study area, sampling technique is applied. A 5% of the total households from each area were covered by the study.

For questionnaire survey all the SDSs were numbered randomly and the total number of questionnaire administered was 200.

Investigation on Secondary Disposal Sites

The questions of field survey for gathering the required information about the existing situation of SDS and answers from city dwellers and other stakeholders were recorded and hence analyzed using SPSS 17.0. However, some important issues, present situation of SDSs and the feedback about SDSs as the outcome through SPSS analysis as presented and hence discussed in followings.





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Figure 17 Detailed geo-referenced base map of Khulna city with road network data information.

FID Shape* 12 Point		Shape *	NAME	Туре	Category 5	
		Point	КМСН	HC-2		
	13	Point	Khulna Sadar Hospital	HC-2	5	
	14	Point	Khulna Zilla School	HC-2	5	
	15	Point	Nirala	HC-2	5	
	20	Point	Khalishpur Sakha office	Open	5	
	30	Point	Inside Navy Camp	HC-2	5	
	7	Point	Rupsha CSS	HC-1	4	
	8	Point	Sibbari Moor	HC-1	4	
	0	Point	Goalkhali Navy Collony	HC-1	3	
	1	Point	Goalpara Electricity Plant	HC-1	3	
1	2	Point	In Front of Boyra Police Line	HC-1	3	
	3	Point	Banorgati(25 No ward)	HC-1	3	
]	4	Point	Polli Mongol Madrasha	HC-1	3	
	5	Point	Hotel Millinium	HC-1	3	
٦	6	Point	PTI Moor	HC-1	3	
1	9	Point	KDA New Market	HC-1	3	
	10	Point	Shipyard	HC-1	3	
]	11	Point	Hotel Kadar	HC-1	3	
1	16	Point	Rail Station	HC-1	3	
1	18	Point	Sonadanga - Kacha Bazar	Open	3	
]	21	Point	Khalishpur graveyard (Goalkhali)	Open	3	
٦	22	Point	Khalishpur new market	Open	3	
٦	23	Point	Khan Jahan ali road - Badsha Mia Clinic	Open	3	
1	27	Point	Rupsha Bus-stand Moor	Open	3	
1	28	Point	Islam Comissionars House	Open	3	
1	17	Point	Sonadanga - Dada Store	Open	2	
1	19	Point	Customs office	Open	2	
1	24	Point	Shaheber Kobor Khana	Open	2	
1	25	Point	Boyra Bazar Area	Open	2	
1	26	Point	Doulatpur Poly Clinic	Open	2	
1	29	Point	Tutpara - Darogapara	Open	2	

Figure 18 attributes of point from ArcGIS



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Figure 19 Optimized route of SDS at KMCH.



Figure 21 Optimized route of SDS at Sibbari moor.



Figure 20 Optimized route of SDS at Khualishpur Sakha Office.



Figure 22 Optimized route for SDS at Goalkhali and Doulatpur.



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Figure 23 Optimized route of SDS at Goalkhali Navy Collony

Figure 24 Optimized route of SDS at Banorgati



Figure 25 Optimized route of SDS at Hotel Millennium Moor



Figure 26 Optimized route of SDS at KDA New Market



RESULTS AND DISCUSSIONS

Important Issues from Questionnaire Survey

To investigate the present scenario of SDS located in and around Khulna city for MSW management, questionnaire survey among 200 responsible people and stakeholders' has been conducted. The important issues from the questionnaire survey which has been conducted until the end of this study as presented in Tables 1-3 and also in Figures 4-6. Experimental result reveals that among 200 responsible people and stakeholders' about 124 (62%) people has SDS, 76 (38%) has no SDS near their area.

On the constraints, after conducting the questionnaire survey among 200 responsible people and stakeholders', SPSS analysis was performed and the outcome is presented in Table 2 and also in Figure 9. In this section, the survey was covered who collects the generated MSW from the household. It was noticed that, among 200 responsible people and stakeholders, non-government organization (NGO) collects 60 (30%), community based organization (CBO) 10 (5%), KCC 120 (60%) and others 10 (5%) of MSW from the household. Here it is interesting to note that after conducting the questionnaire survey among 200 responsible people and stakeholders and their response was about 150 (75%) has dustbin, where 50 (25%) has no dustbin near their locality as shown in Table 3 and Figure 6.

Present Situation of SDSs from Questionnaire Survey

Present situation of SDSs located in and around the Khulna city for MSW management from the questionnaire survey has been conducted as presented in Tables 4 to 8 and also in Figures 7 to 11 and hence discussed in followings. The survey was also carried out about the collection prototype of MSW from SDS among 200 responsible persons and stakeholders', it was noticed that KCC collects MSW from SDS 166 (83%) once per day, 30 (15%) twice per day and 4 (2%) more and shown in Table 4 and Figure 7.

Here, it is interesting to note that after conducting the questionnaire survey among 200 responsible person and stakeholders', SPSS analysis was performed. Result showed that the present situation of SDS was very good said by 20 (10%) people, good 20 (10%), average 110 (55%) and bad 50 (25%) people as shown in Table 5 and also in Figure 8. Moreover, survey among 200 responsible person and stakeholders reveals that KCC clean and collect MSW from SDS was said regularly by 68 (34%) people, irregularly 108 (154%) and said often by 24 (12%) people as shown in Table 6 and also in Figure 9.

Among 200 responsible person and stakeholders', KCC collects waste from SDS was said at morning by 100 (50%) people, at noon 28 (14%), afternoon 68 (34%) and said at night by 4 (2%) people as shown in Table 7 and also in Figure 10. Moreover, among 200 responsible person and stakeholders', biggest problem around SDS in and around Khulna city is odor was said by 90 (45%) people, dirty streets 56 (28%), rubbish heap 40 (20%) and was said flies by 14 (7%) people as shown in Table 8 and also in Figure 11. **Feedback about SDSs from questionnaire survey**

The feedback about SDSs from the questionnaire survey which has been conducted until the end of this study as presented in Tables 9 to 11 and also in Figures 12 to 15. On Table 9 and Figure 12, it is seen that among 200 responsible person and stakeholders', 44 (22%) people things the improvement of the present situation of SDS is possible by KCC, NGOs and CBOs 40 (20%), awareness 88 (44%) and legislation 28 (14%) people.

Based on Table 10 and Figure 13, it can be concluded that among 200 responsible person and stakeholders', authority should collect MSW from SDS was said once per day by 40 (20%) people, twice per day 104 (52%), and more 56 (28%) people. Here, it can be concluded that 30 (15%) people things the better type of SDS is container, concrete bin 70 (35%), haul container 82 (41%) and others 18 (9%) people as presented in Table 11 and also in Figure 13. However, authority should collect MSW from SDS at morning was said by 86 (43%) people, noon 32 (16%), afternoon 60 (30%) and night 22 (11%) people as shown in Figure 15.

Summary of Feedback from the People about MSW Practices

To fulfill the research objectives, five important issues have been formulated from the questionnaire survey conducting among 200 responsible person and stakeholders' as shown in Figure 16. The Figure 16 reveals that after conducting the questionnaire survey feedback from responsible person and stakeholders' about the satisfaction of present situation of SDSs was 60, 93, 47 and 0 for disagree, neutral, agree and strongly agree, respectively. Moreover, feedback against the modified of improved the present SDSs were 37, 3, 52 and 108 for disagree, neutral, agree and strongly agree, respectively. Here, it is clear that the present SDSs located in and around Khulna city should be improved immediately. However, the Figure 16 depicts that the route of collection and disposal of MSW from SDS to UDS must have relocated of re-planned instantaneously.



Table 1	Results	of SPSS	analysis	about SDS	near yo	our area
					/	

	Values Frequency		Percent		١	Valid percent		Cumulative percent	
	Yes		124	6	62.0		62.0		62.0
	No		76	3	38.0		38.0		100.0
	Total		100	100.0		100.0			
Τa	able 2 Results of SPSS analy		is ab	out colle	ctio	on media of gen	erat	ed MSW from household	
	Values	s Frequency		Percent		N	/alid percent	(Cumulative percent
	NGO		60	3	0.0		30.0		30.0
	CBO		10		5.0		5.0		35.0
	KCC		120	6	60.0		60.0		95.0
	Others		10		5.0		5.0		100.0
	Total		200	1	100.0		100.0		
Table 3 Results of					SS analys	is a	about dustbin w	ithin	500 meter
	Values	Fre	quency	Pe	rcent	١	/alid percent	(Cumulative percent
	Yes		150	7	5.0		75.0		75.0
	No		50	2	5.0		25.0		100.0
	Total		200	10	0.00		100.0		
Table 4 Results of SPSS analysis about collection prototype of KCC of MSW from SDS									
	Values Freque		Frequer	icy	Percent	t	Valid percent		Cumulative percent
	Once per day		166		83.0		83.0		83.0
F	Twice per day		30		15.0		15.0		96.0
	More		4		2.0		2.0		100.0
Total		200		100.0		100.0			
Table 5 Results of SPSS analysis about the present scenario of SDS						nario of SDS			
	Values		Frequen	Cy .	Percen	t	Valid percen	t	Cumulative percent
Very good		ł	20	<i>.</i>	10.0		10.0		10.0
Good			20		10.0		10.0		20.0
Average			110		55.0		55.0		75.0
	Bad		50		25.0		25.0		100.0
Total			200		100.0		100.0		
	Table 6 F	Result	s of SPSS a	inaly	ses about	t th	ne KCC clean and	coll	lect waste from SDS
	Values	F	requency		Percent		Valid percent		Cumulative percent
	Regularly		68		34.0		83.0		83.0
	Irregularly		108		54.0		15.0		96.0
	Often		24		12.0		4.0		100.0
[Don't collect		0		0.0		0.0		100.0
	Total		200		100.0		100.0		
	Table	e 7 Re	sults of SP	SS ar	nalyses at	οοι	it the KCC collec	ts M	ISW from SDS at
	Values	F	requency		Percent		Valid percent		Cumulative percent
	Morning		100		50.0		50.0		50.0
	Noon		28		14.0		14.0		64.0
	Afternoon		68		34.0		34.0		98.0
	Night		4		2.0		2.0		100.0
	Total		200		100.0		100.0		



Values	Frequency	Percent	Valid percent	Cumulative percent
Odor	90	45.0	45.0	45.0
Dirty streets	56	28.0	28.0	73.0
Rubbish heap	40	20.0	20.0	93.0
Files	14	7.0	7.0	100.0
Total	200	100.0	100.0	

Table 8 Results of SPSS analyses about the biggest problem around SDS

Table 9 Results of SPSS analysis about How to improve the present situation of SDS

Frequency	Percent	Valid percent	Cumulative percent
44	22.0	22.0	22.0
40	20.0	20.0	42.0
88	44.0	44.0	86.0
28	14.0	14.0	100.0
200	100.0	100.0	
	Frequency 44 40 88 28 200	Frequency Percent 44 22.0 40 20.0 88 44.0 28 14.0 200 100.0	FrequencyPercentValid percent4422.022.04020.020.08844.044.02814.014.0200100.0100.0

Table 10 Authority should collect waste from SDS

Values	Frequency	Percent	Valid percent	Cumulative percent
Once per day	40	20.0	35.0	35.0
Twice per day	104	52.0	40.0	75.0
More	56	28.0	16.5	91.5
Total	200	100.0	100.0	

Table 11 which type of SDS is better?

Values	Frequency	Percent	Valid percent	Cumulative percent
Container	30	15.0	15.0	15.0
Concrete types	70	35.0	35.0	50.0
Haul container	82	41.0	41.0	91.0
Other	18	9.0	9.0	100.0
Total	200	100.0	100.0	

Optimizing Routes for Collection and Disposal of MSW

Geographical Information System (GIS) Approach: GIS can make the analysis of the situation along with a future trend could be predicted which will help in planning for the long term solution. This system propose the collection of data from different sources and formation of map layers like, ward and city map, demographic map showing the area wise population distribution, MSW generation map of different areas, existing MSW collection and disposal pattern from SDS to UDS, employment distribution in different wards and existing route plan of MSW lifting [12, 13]. From these layers the analysis can be achieved to derive the logistics and spatial planning [14]. There are many suggestions in this spatial planning proposal which are said to be considered while working in GIS, they are (i) identification of exact location of MSW bins with GPS demarcating on the base map; (ii) maintaining a record of SDSs; (iii) a map showing the road network in different areas; (iv) a map showing the distances between the bins; (v) location of the SDSs; (vi) record of available vehicles and equipment for MSW management; (vii) allocating a unique number to all the SDSs so it can be easily and quickly located in case of any complaint registered or planning and maintenance; (viii) maintaining a record about the type of SDSs and (ix) record of the responsibilities and assignment of work, equipments, vehicles etc. of the MSW maintenance and also the logistics information about the transportation involved in the system.



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Table 12 summery of optimized route for SDS to ODS with vehicle recommendation							
SDS located at	Type	Route length	Vehicle (truck) to be				
SDS located at	турс	(m)	assigned				
Khulna Medical College Hospital	HC-2	11507	Double HC				
Khulna Sadar Hospital	HC-2	9132	Normal				
Khulna Zilla School	HC-2	10454	Double HC				
Nirala	HC-2	8217	Double HC				
Khalishpur Sakha office	Open	15460	Normal				
Inside Navy Camp	HC-2	13458	Double HC				
Rupsha CSS	HC-1	12381	Single HC				
Sibbari Moor	HC-1	8823	Single HC				
Goalkhali Navy Colony	HC-1	17126	Single HC				
Goalpara Electricity Plant	HC-1	18737	Single HC				
Banorgati	HC-1	7791	Normal				
Polli Mongol Madrasha	HC-1	7892	Normal				
Hotel Millennium	HC-1	9110	Normal				
PTI Moor	HC-1	9262	Single HC				
KDA New Market	HC-1	9796	Single HC				
Shipyard	HC-1	14840	Single HC				
Hotel Kadar	HC-1	8026	Normal				
Rail Station	HC-1	9063	Normal				
Rupsha Bus-stand Moor	Open	12160	Normal				
Near Islam Commissioner's House	Open	7791	Normal				
Tutpara	Open	11692	Small				
Boyra area (Bazar Area + Police Line)	Open	13801	Normal				
Sonadanga Kacha Bazar+Dada Store)	Open	10188	Normal				
Goalkhali + Doulatpur	Open	21288	Normal				
Khalishpur + Customs office	Open	17467	Normal				
Khan Jahan road + Shaheber Kobor Khana	Open	8145	Normal				

Table 12 Summery of ontimized route for SDS to LIDS with vehicle recomme	ndation	

The maps in the form of mxd base map were collected from KCC, Khulna. Usually the corporation office has an original record copy from which the base map was developed. The detailed map of case study area had the information about the detailed road network stream. Later these maps were imported in the Arc View and joined together. Then the base map of Khulna city was geo-referenced. The detailed map of the case study area was then located on its position on the city map then the maps were digitized to enter the spatial information in vector form. Different information was spatially located on the maps in point, line and polygon features. The detailed base map of case study area with vector data information in different features is seen in Figure 17.

GIS data is any type of information that holds both the spatial information and attributes. GIS data is used in this way to store information about large geographic areas. For example, a municipality will likely have property information, illustrating individual land parcels or lots geographically. For each one of these parcels, the municipality will also store attribute information such as the contact information of the owner and the street address of the home. When using shape files, the data can be presented in 3 different forms: points, lines and polygons. For this municipal example, land parcels will be represented by polygon data. In this study, the SDSs were fed as points.

Additional attribute data can be added to the database by joining a table which contains the new attributes to an existing table already in the GIS. To join these tables together a common field must be present. Most GIS can then use the resulting table to display the new attributes linked to the entities. Figure 18 represents the attributes of point on ArcGIS.



Network Analyst with a Concentration on Optimal Routing Network analysis is a widely used analysis technique useful for route optimization. Two example network analysis techniques would be the allocation of values to select functions within the network to determine zones, and the determination of shortest path between connected points or nodes within the network based on attribute values [15, 16]. Network Analyst can discover the obvious way to get from one location to another or the best way to visit several locations. The locations can be specified interactively by placing points on the screen, simply by entering an address, or by using points in an existing feature class or feature layer. The very best route can be determined for the order associated with locations as specified by the user. Alternatively, ArcGIS Network Analyst can determine the best sequence to visit the locations [17, 18]. Whether finding a simple route between two locations or one that visits several locations, people usually try to take the best route. Hence, the best route can be defined as the route that has the lowest impedance, where the impedance is chosen by the user. Hence, some conditions were place into consideration for route optimization of (i) starts from KCC garage, collect MSW from SDS(s) and stops at UDS; (ii) optimum travel distance; (iii) least road requirement for vehicle movement; (iv)specific vehicle for specific type and category of SDS and (v) then routes were optimized using network analyst of ArcGIS 9.2.

Here, it is interesting to note that the optimized route using network analyst of ArcGIS 9.2 of SDS at KMCH to UDS as presented in Figure 19. On the other hand, the optimized route of SDS at Khualishpur Sakha Office, Sibbari moor, Goalkhali and Doulatpur, Goalkhali Navy colony, Banorgati, Hotel Millinium Moor and KDA new market to UDS as the output from the ArcGIS 9.2 is presented in Figures 20 to 26, respectively. Moreover the information about the optimized route of SDS at different study area to UDS is also presented in Table 12.

CONCLUSIONS

In this study it was intended to investigate the present situation of SDS conducting questionnaire survey and field observations. This study also emphasis for optimizing the collection and disposal route of MSW from SDS to UDS. There are different routes for the three categories of SDSs and four types of MSW collection vehicles. These statistics were given to have the idea of the new MSW management system by using the proposed route network. It can be a good decision support tool for MSW transport, fuel consumption, work distribution amongst the vehicles for load balance and generation work schedules for both employees and vehicles.

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