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Geospatial Management of the Solid Waste System (A Case Study of Rawalpindi City)

Sana khushi (Corresponding author)
Institute of Geology, University of the Punjab,
Lahore, Pakistan, E-mail:sana.khushi@yahoo.com

Sajid Rashid Ahmad,
Institute of Geology, University of the Punjab
Lahore, Pakistan. Email: sajid.geo@pu.edu.pk

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Abstract

Improper Solid Waste management is a global problem. Solid waste management is not just a technical issue but it also has socio-political and cultural dimensions that need solution through policies, administration, re-orientation, organizational arrangements. The important thing is that the total solid waste generated is not equal to the solid waste reached to the dumping site. This study includes the details about total quantity of solid waste produced, its collection, physical structure, and transference, treating and dumping of solid waste in Rawalpindi city. Its focuses GIS based Solid Waste Management through Collection and Routing.

The use of GIS to locate the position of waste bins is based on convenient distance to households, maximum service coverage and consideration of physical and socio-cultural context of the service area. GIS use to locate the position of waste bins is based on suitable space to households, maximum service coverage. A bin location point covers the built up areas. After the calculations of the required bins, a map is generated. Waste bins are located at the shoulders of roads after excluding unsuitable areas. Walk time service area analysis for dropping of the waste from houses is calculated. By using the network analysis service area the calculated walk time will be 3, 5 and 10 minutes. Proposed model include the arrangement of bins, routing, optimal routing. The generation of spatial data base bin locations, verify the same data using satellite information. Waste storage, width of the roads, accessibility of the space and the travel distance from the home. Dataset model analyze on the base of four layers. These are stops, point barrier, line barrier, polygon barrier and polygon barrier. Route calculates between any two stops and give results.

The current work examined the insufficiency of existing collection bins and their service areas. 5 cubic meter bin keeps 2.5 tons waste. Every bin is placed along the main roads. Total Rawalpindi city area is 276 sq km. 46 Km area can be accessed through walk time of 3, 5 and 10 minutes which is most of the built up area. 17% area of the city can access bin by the walk time of 3, 5 and 10 minutes. The Proposed GIS model used for routing and planning uses statistics on the shortest routes (in terms of travel time or distance) between pairs of waste containers and between waste Bins and waste dumping site.

Keywords: Waste management, Geographical information system, disposal site, open heaps.

1. General Introduction

In Pakistan, there is poor solid waste management system and disposal collection system in many cities. Solid waste linked actions for poor waste picker's affectation a serious risk to community healthiness as well as a visual problem in the city (Sengtianthr et al., 2004).

Improper Solid Waste management is a global issue. Solid waste management is not just a technical issue but it also has socio-political and cultural dimensions that need solution through policies, administration, re-orientation, organizational arrangements and informed population. Excessive amount of waste can harm human heath in a very bad way through the drains clogging, formation of stagnant ponds and also providing breeding place to mosquitoes and flies. Moreover, due to the lack of proper disposal sites, much of the waste is found near and around the dumping grounds, open heaps, containers, ponds, rivers and agriculture land. Solid waste is generally defined from house hold and non-hazardous waste. All types of solid waste are a problem worldwide particularly in developing countries (Arebey, 2011). Recently it is projected that 54,888 tons per day waste is produced in Pakistan (EPMC Estimates, 1996).

According to the research, some of the major cities in Pakistan are suffering growth rate of 3.67% to 7.42 % (EPMC Estimates, 1996), which is more than the overall growth rate. Due to this reason it is estimated that these cities will have double population in the next 10 years. The cities with high population density generate much amount of solid waste. Generation of solid waste is increased with an increase in population (EPMC Estimates, 1996). Geographical information system is involved in Solid waste management for the cost effective collection, finding the appropriate number of bins required and the location of the bin placed (SRR, S. K. (2012). The efficient use of GIS based upon the quality and quantity of the data (Al-Hanbali 2011).

2. Objectives of Study:

- The main objectives of this study are given below:
- Preparation of maps demonstrating the current situation.
- Demarcation of uncollected waste.
- Assess bin according to the population.
- Identify the location of bin where needed.
- Routing efficiency of the solid waste collection.

3.A CASE STUDY OF RAWALPINDI:

This study is done in one of the 36 districts in Punjab, Rawalpindi is the north most city of the Punjab. It is 290 km northwest form Lahore and 11 km southwest form Islamabad (National capital).Rawalpindi can be approached from Lahore by GT road or Motorway M-2. It is located at Lat/Long 33.6000° north, 73.0500° east. It is the fourth largest city of Pakistan. After Islamabad established, the economy of the Rawalpindi grew fast. Solid waste generation of Rawalpindi urban area is 800 tons per day. It is the center point for productive agriculture region and also famous for textile, chemical and metal working industries. Rawalpindi is also important for the military headquarter post since 1850. Many tourist stay there before travelling to the northern areas of Pakistan. Have many bazaars, parks, and people from other culture and community attract shoppers from all over the Pakistan (Figure 1).

The reason behind to select this city is that, Rawalpindi faces more solid waste management problem. This city generates total waste 800 tons from which 600 tons is lifted by sanitary workers and remaining waste produces smell and bacteria in the streets and around other areas. That will cause many diseases. Government is going to take action for the betterment of Rawalpindi.

The municipal services department of the Rawalpindi City has also been facing problems like desalting of the drains and proper disposal of the solid waste. Most of the facility related information in municipalities are geographic, that's why municipalities and administration organizations use computer technologies and database technologies to stock, process, and execute the data proficiently (Dhlamini, 2011)
Presently, local waste in Pakistan has not been carried out in an enough and appropriate way in collection,

transportation and dumping irrespective of the size of the city. Solid waste organization by municipalities as a whole is relatively ineffective as it gathers only 51-69% of the total waste generated. No assessing facilities are installed at dumping sites.

The searchers play a significant role as they distinct recyclable at various steps of existing solid waste management. Dangerous hospital and manufacturing wastes are being basically treated as usual waste. Open burning of waste particularly non-degradable mechanisms like flexible bags are adding to air pollution. Municipalities have been stated to spend significant portion of their funds on solid waste management but as a return obtain nothing (no tax) from the population being helped. Presently local waste in Pakistan has not been correctly carried out.

There is need of the management system for solid waste in Rawalpindi. The main objective is to plan a cooperative mechanism, to improve the operation of the right strategies, rules and regulations.

Traditionally solid waste management of any city is responsibility of any city local government. However, with increasing the source of solid waste generation and awareness about the regulation of the waste, various institutions involve in the management for the solid waste directly and indirectly (supportive way). GIS technology is used for effective formation, checking, and implementation for the services being delivered (Kyessi, 2009).

In the direct waste management service involves in different stages chain i.e. collection, transportation, retreatment and disposal. In other way institutes help out for enhancing the efficiency through the information providing, awareness raising, technical help and financing the system. Waste management is the collection, transportation, treating, dumping, and monitoring of waste materials (Senthil et al., 2012).

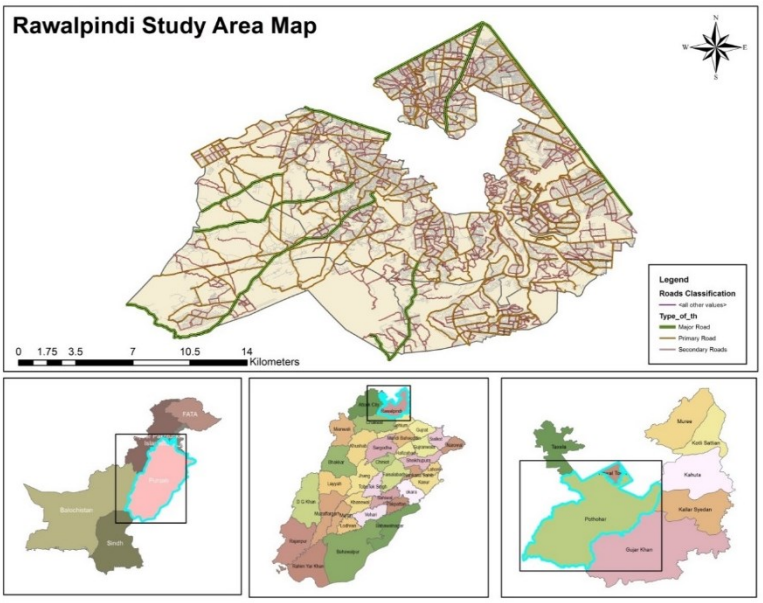

Figure 1: Rawalpindi Study Areas

Total bins required calculation: Rawalpindi city has two towns that are Rawal town and Pothohar town. Rawal town is densely populated area and generates more waste, that's why it needs more bins for waste keeping. The door to door collected waste is dropped in nearby collection bin. Since the collection frequency is varying from bin to bin so it is needed to find the nearest place to drop. If the waste is more than the volume of the bin, the waste shall fall around the bin. The whole activity of solid waste managing destination involves determining the type, capacity, location of the facility and scheduling. (Leao et al., 2001)

By using the union council as administrative level and population as primary key, we can calculate the total one day waste of every union council and get the required bins count. It is projected that total per capita waste

in the urban area is from .6 to .8 KG and we can suppose per capita waste may be .65 KG per person. All of the Union councils of Rawalpindi have been selected as the research area. In the first step primary data collection for bins location, i.e. Population, waste generation rate, bin capacity, number of bin allocated and also the road network. Current location of the bins is found by the use of GPS (Global positioning system). Thirty two bins were located in the main city area and the need is much more than this. The city produces waste of 800 tons in one day. Waste is carried through the mechanical sweeping. The collection capacity is varying from bin to bin depending on the waste generation change rate. If bin is located on the road is filled completely than the waste falls around the bin. UC area is 276 Sq. km and the total household in the Rawalpindi City is 203430. Number of existing working staff is 1606, working on the regular bases in this Union council. It means one worker is serving 634 people in the Rawalpindi City. The process of bins location and service area (buffer analysis) is shown in Figure 2.

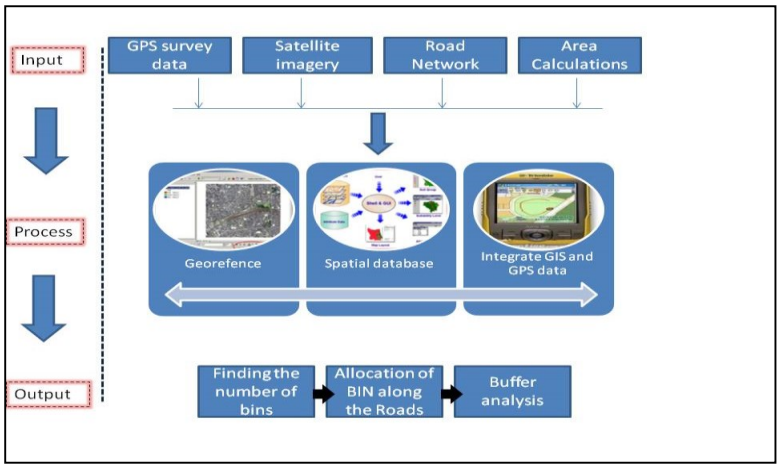

Figure 2: Service Area Analysis Flow Chart

Initially the number of bins was calculated using following formula:

Estimated bin= (UC Population*.65 kg /1000)/2.5

According to WHO(World Health Organization) recommendation and Shaikh Moiz Ahmed (2006), Illeperuma.I.A.K.S et al (2010) statement, the preferable walking distance of the people to drop their municipal solid waste to the collection bin is less than or equal to 100m. Estimation the total number of persons in a house and quantity of waste generated from a household per day and allocation of bins along the road at the union council level.

We have data of population, Union council boundary, area of the boundary. According to LWMC, per person waste weight in Pakistan's big cities is .65 kg person and 5 cubic meter solid waste bin is placed on the roads. Required bin calculation is done using Field calculator and applying above formula in Union council Boundary shape file.

Multiply Every Union council population with Total waste generated by every person. The use of GIS to locate the place of waste bins is based on suitable distance near households. For example UC no.79 have 15346 Person Living and the everyday total waste generated ion UN.79 will be 9974.9 Kg. 9974.9 Kg will be 11 tons. According to the Table 3.2 the required bin of the UC.79 will be 4.Bin location show in Figure 3.

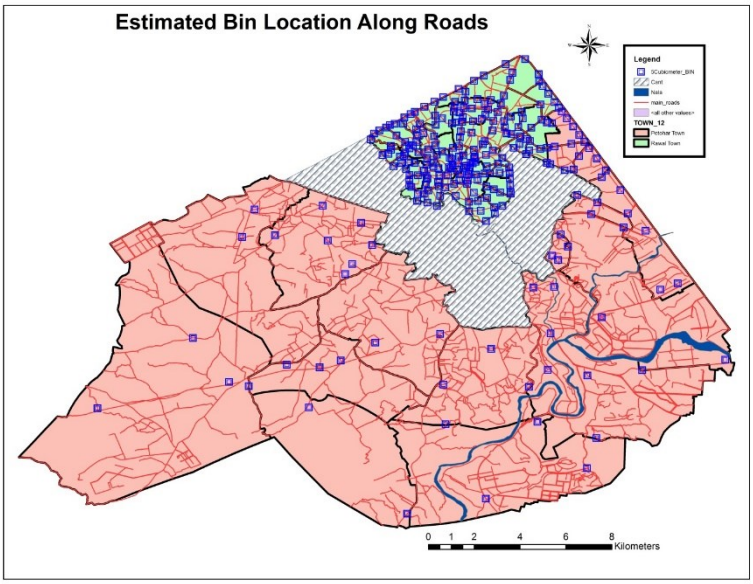

Figure 3: Estimated Required Bins along the Roads

Service Area Analysis (Total Area served)

The use of GIS to locate the position of waste bins is based on convenient distance to households, maximum service coverage and consideration of physical and socio-cultural context of the service area (Aremu, 2011). After the calculations of the required bins, a map is generated. Waste bins are located at the shoulders of roads after excluding unsuitable areas. Walk time service area analysis for dropping of the waste from houses is calculated. As the solid waste trucks cannot collect door to door waste, so we assume that the collecting points of the solid waste are bins, placed every UC at the road side. Bin is located after every hundred meter so everyone can access it easily to drop their home's waste. By using the network analysis service area the calculated walk time will be 3, 5 and 10 minutes. Everyone can walk 3 to 10 minute for dropping waste away from their homes properly. This analysis can be done though the Service area analysis.

Using the service area analysis calculates service areas around bins position on a network. A network service area covers all accessible streets at the 3, 5 and 10-minute from the bins location (Figure .4).

Road Network Optimal routing model:

From transfer stations, waste has to be transported and disposed of. These activities can be represented on a transport network and enable a modeling approach using GIS technique (Karagiannidis, 2004. Network attributes have five basic properties: name, usage type, units, data type, and use by default. Additionally, they have a set of assignments defining the values for the elements. Initially calculate direction, length of the roads, speed, and time using the for time formula. NA can help out in daily procedures for waste transporting, load Balancing, dealing fuel intake and also the work plan for employees and vehicle (Ghose et al., 2006).

Formula for the time

=Length/speed

For miles/h to m/s conversion

Calculate the distance

Speed on major road=80km/h
Speed on primary road=60km/h

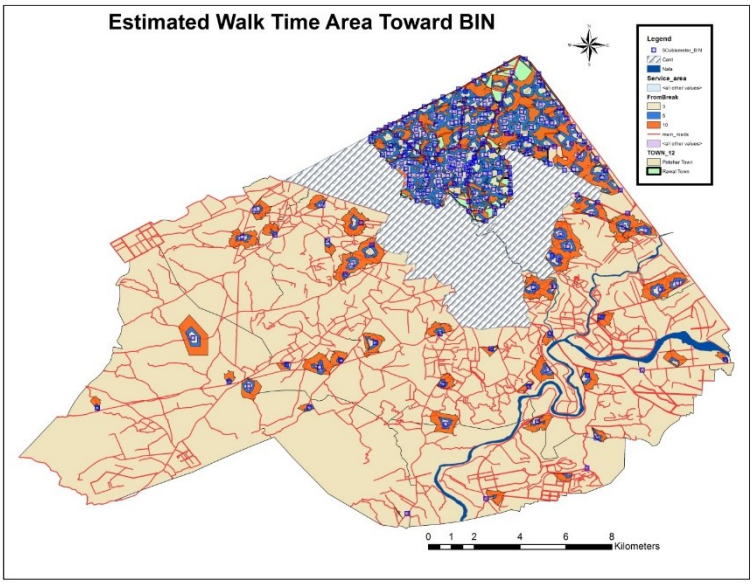

Figure .4: Service Areas.

Network Analysis is powerful technique to calculate the routing for solid waste in this study. It calculates the travel direction, time, distance and alternate route. The Network Analysis (NA) model includes Turns restriction, Speed restrictions, Height limitations and the traffic condition on altered times of the day. NA model solve the problem to find the route to access every bin placed in Union Councils and back to Transfer Station. This analysis will reduce the Fuel cost and save time. NA model determines the best route by using an procedure which finds the shortest path. NA is a very powerful technique to perform analysis on Network base data including routing, travel direction, closest facility and service area analysis. Using NA model in Rawalpindi Roads network dataset resolve traffic issue on roads while waste routing. Solid waste vehicle can face Heavy traffic jam, under constructed roads, one way road or a barrier. NA route model finds the shortest route with a set of stops with minimum cost. The path calculated depends on which node is visited and in which order. At every turn of the node NA window shows the travel time of the particular road, length of the road, starting and ending node and the map of every turn.NA Model Have four layers which are stops, point barrier, line barrier, and route and polygon barrier. Stops are the input of the data and route is output as a route. All barrier shows as the hurdle on the way of vehicle, route finder takes it as a restricted path and finds some best alternate. To find a best route minimum two stops are required and then solve to calculate it (**Figure 6)**. Graphic Pick 2 is the first stop and graphic Pick 3 is the second stop and The Total_Minutes is the travel time (Figure **5**).

Shape	Name	FirstStopID	LastStopID	StopCount	Total_Minutes
Polyline M	Graphic Pick 2 - Graphic Pick 3	65	86	2	1034.992265

Figure 5: Attribute results

Network analysis works on the base of initial data processing steps described above.

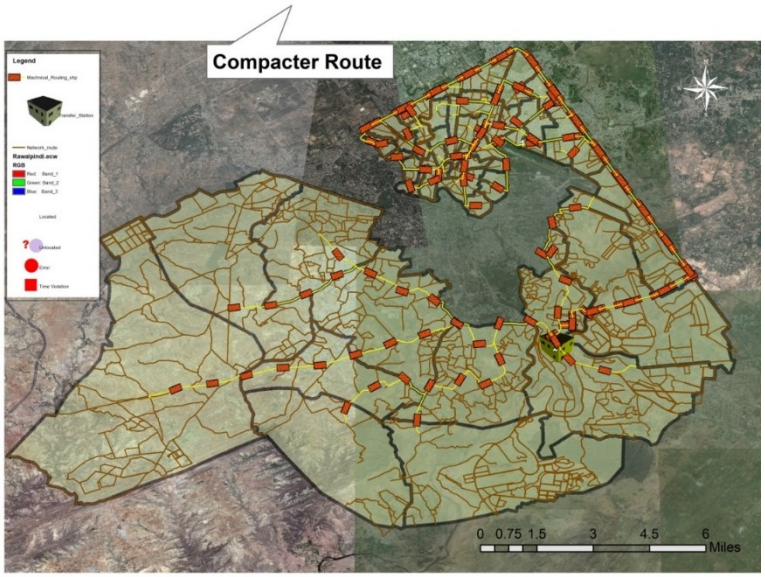

Figure 6: Total Compacter Route of the City

RESULTS AND DISCUSSIONS:

Then obtained numbers of bins were allocated at new locations based on the following criteria, With reference to existing bin location, the road network and population density, service area, the land use pattern of the proposed collection bins was also analyzed with creating service area analysis around the collection bins by following three cases. BINS of the size 5 m3 covers the most of the area and successfully collect waste of the one day. However we locate all the BINS in each 100 meter distance but distance does not matter in the case of vacant place, in commercial area where more BINS are required in less distance. By the service area analyses we can see the more bins serve the same area that will increase the collection process. By this research we have the calculated requirement of BINS and waste production capacity in the union council and proposed bins serve and cover above 17% city area.

After the mathematical calculation and GIS application we find the bin along the road and the distance between two bins will be 100 meters. These bins will be enough for 62 union councils of Rawalpindi city .Service area analysis prove that two bins can also serve the same area.

Some important limits were taken into account, such as the streets' orders, no U-Turns rules and also, the fact that the truck should follow true-shape route. Furthermore, Network Analysis was asked to show the outcomes in meters, as the distance standard was selected, and to rearrange the stop-points in order to find the shortest route. It is worth declaring that, in the distinct case where some piece of refuse causes traffic problems, Network Analyst can be asked to find the shortest route starting from this definite point, so as to release the traffic. Finally, pushing the "solve" button of Network Analyst, the closest route for the solid waste collection was formed. In this work we improve the solid waste route for vehicle in Rawalpindi city area by using Network Analysis. With the GIS method, best route was identified which found to be cost operative and less time consuming when matched with the current run route. The software based analyses is quick / fast and easy to appreciate as compared to manual examines. So software examines also good choice for these types of studies.

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