SOLID WASTE MANAGEMENT AND SALT LAKE MUNICIPALITY- A GIS AND MIS APPROACH

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1. INTRODUCTION

Bidhannagar or Salt Lake City as is a planned satellite township in West Bengal. It was developed between 1958 and 1965 to accommodate large number of population of Kolkata. It is now one of the important hubs for Information Technology in the Kolkata. The Chief Minister of West Bengal, Dr. Bidhan Chandra Roy, was main architect in formulating the plan to build this satellite area, and later the township was named Bidhannagar in his honor. The city was built on a reclaimed salt-water lake, which gave rise to its popular name of "Salt Lake City". The development of the area was done in "Sectors". The plots were classified as residential, residential (shop-allowable), commercial, institutional and industrial. By 1965, Sector-I was complete and by 1969, Sector-II and Sector-III were built for occupancy. After that the industrial Sectors IV and V (the location of the IT industries) were developed. The Sector IV contains Nicco Park — the first amusement park of eastern India with 40 acres (160,000 m2) of land and the Nalban Boating Complex and so also the under-privileged area of Sukantanagar. The 12.35 km² area of the town initially composed of 12873 plots of land apart from 87 housing estates and blocks, got built up. Recently, the land area of this township has almost doubled to 33.5 km² due to the incorporation of Duttabad, Sukantanagar, Nayapatti, Dhapa-Manpur and Mahishbathan areas. The whole of Duttabad remains as an underdeveloped area till date [1,2].

For effective urban and environmental management, solid waste management plays an important role [2,3]. Current population of Kolkata city is 5,080,519 and initially Salt Lake was planned to accommodate nearly 4, 50,000 population. In India, municipal solid waste management, like most of other infrastructural services has come under great stress, consider low priority areas, solid waste management was never taken up seriously either by public or by concerned agency or authorities and now the large amount of waste is threatening our heath, environment and well being (Chouhan and Reddy 1996, Mazumdar 1994) [4,5,6 & 7]. Salt Lake Municipal Corporation is responsible for better management of solid waste that are produced everyday and the present study has been carried out in the urban environment of Salt Lake in the year 2011 to understand the problems and perspective associated with solid waste management in the city.

To provide a waste management service which can be acceptable on existing financial constrains. This action plan proposed two elements of the plan firstly the creation of an efficient Management Information System (MIS) & Geographical Information System (GIS) and secondly the provision of planning and management such that there are possibilities of improvement in financial and institutional support. Due to the financial constrains it was suggested to incorporate those options which can promote the improvement in the system without a major capital investment. So it is proposed to create the MIS and GIS information.
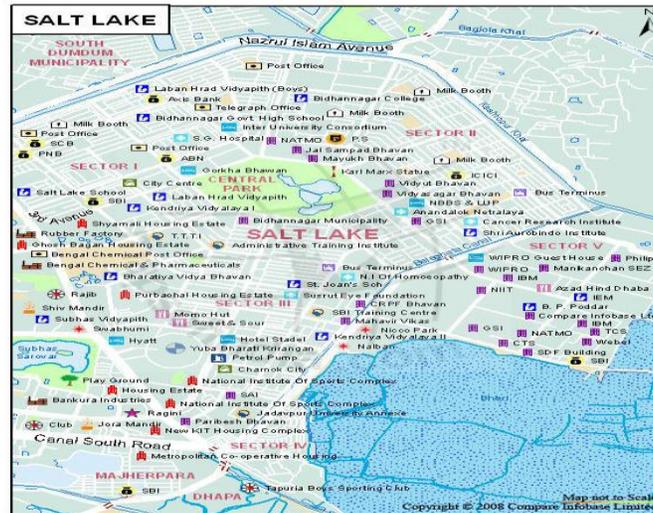
Salt Lake Map

2. PROBLEMS ASSOCIATED WITH SWM

According to Ogra, A, 2003 [6], "Municipal bodies are unable to prove a 100% efficient system and even are not able to reach the efficiency of 60%". This is not because the municipality is not doing their work properly or due to work negligence, but it is due to the old conventional working methods which need to be upgraded with the advanced system like GIS and a better management system. The data should be managed in an integrated way to reduce the complexity of different issues related to the function of the work involved in the waste management system. The solid waste management in Salt Lake City appears to be inadequate and needs up gradation. The solid waste has to be disposed off scientifically through sanitary landfill and recyclable portion of the waste should be salvaged. Segregation of recyclable material would also lead to reduction in quantity of solid waste for final disposal. Higher priority needs to be assigned to the management of municipal solid waste by the local authority and a system approach needs to be adopted for optimizing the entire operation of SWM encompassing segregation at source, timely and proper collection, transportation routes and types of vehicles and development and proper operation of sanitary landfill site. The density of population along with number of offices and institutions are continuously increasing thus there should be effective management activity for managing the solid waste which is generated daily in Salt Lake area.

On the other side the municipal authorities had their reasons for this mismanaged of the waste maintenance as follows:

(i) The citizens do not throw the waste inside the bins so it often lies outside and around the bins, making the area around the bin look dirty.

(ii) The waste lifting capacity is quite less in comparison with the amount of waste generated in the city.

(iii) There is also a shortage of manpower, equipments and machinery.

2.1 Other problems due to poor SWM

Now the situation was such that there were several drawbacks of this garbage accumulation and even worse were its consequences, some of them are:

(i) Bad odor is created around the garbage area, making an unbearable environment.

(ii) Poor waste pickers pose a serious threat to public health.

(iii) Animals like cats, dogs, goats and cows come to the garbage in search of food and end up in spreading the garbage around the bins.

(iv)The economic factor is also affected, the market value of a particular area decreases if there is a badly maintained waste area near by as it poses a bad aesthetics.

(v)It overall leaves a bad impression and poses a threat to the environment

3. GEOGRAPHICAL INFORMATION SYSTEM (GIS) APPROACH FOR SWM

There are several areas where the municipal bodies are striving hard to provide best of their services for the betterment of the city. They even follow their methods promptly and perform their duties in a way that could run this system perfectly. In these kind of situations, there has to be a better and a refined system which is developed with

the consideration of all the facts and figures of the situation. This can be achieved with the help of GIS which can handle different data forms like spatial as well attribute data simultaneously. The system seems to fell short in terms of its approaches to maintain a clean environment and it needs to be upgraded and refined. Solid Waste Management is one of the important areas where the problem arises from time to time

The type of dataset which is required is the information about the areas where most waste is generated, the data related to the employees involved in the waste management program. A systematic map with sufficient information related to the waste generated in different areas and even along the roads and junctions.

The working strategies which are being proposed for Municipalities for the situation of the Salt Lake City were as follows:
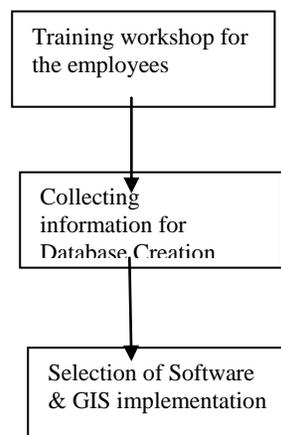
It is found that the data related to SWM is not available on one platform for utilizing it for proper decisions regarding the planning and management. In the existing situation the system lacks supervision of workers and a proper logistic management and spatial planning. Through continuous planning and dynamic management these systems can be designed to have capacity meet demand on a continuous basis. The process of planning can not be stopped and suggested as an ideal for the system as the city situations of waste generation and the service requirements change in due course of time, so the planning also have to be upgraded and reconsidered. GIS can make the analysis of the situation and a future trend can be predicted which will help in planning for a long term.

This system propose the collection of data from different sources and formation of the map layers like, ward and city map, waste generation map of different areas, existing waste bin locations, collection pattern from the bins and employment distribution in different wards. From these layers the analysis can be done to derive the logistics and spatial planning. There are some suggestions in this spatial planning proposal which are supposed to be considered while working in GIS, they are as follows;

(i) Identification of exact location of waste bins, either with GPS
(ii) Maintaining a record of the waste bins
(iii) A map showing the quantity of waste generated in different areas.
(iv) A map showing the distances between the bins.
(v) A record of the employees like, sanitary inspectors, sweepers etc should be maintained. This would help to study and workout the ratio of employees for the assignment of facilities and equipments for the assigned work.
(vi) Identification of existing waste lifting pattern
(vii) Location of the waste dumping ground/landfill site.
(viii) Record of the available vehicles and equipments for the waste management.
(ix) Allocating a unique number to all the waste bins so it can be easily and quickly located in case of any complaint registered or planning and maintenance.
(x) Assigning the responsibilities to the crew members by making groups and allotting them the specific areas of work. This would help in proper distribution of work.

3.1 Planning and management based on GIS and MIS
In planning management it is discussed that the municipal body is responsible for the waste management in the city and therefore there should be a phase wise planning for the implementations of the action plans. As apart of the logistics management and spatial planning for waste management it is important to develop the adoptability of the system for the GIS based proposal. Following is the schematic representation of planning and management based on MIS and GIS:

Training workshop for the employees

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Collecting information for Database Creation

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Selection of Software & GIS implementation

The first phase includes the training workshops for the employees of the municipal departments and other concerned users. This training would help them to get acquainted to the new concepts and technologies of GIS.

The second phase is anticipated to have training on the database management and collection of different information for the attribute data.

The third phase consists of selection of software and implementation of GIS in the area. This new implemented system is supposed to take up the major city waste management issues. In the future proposed works it is suggested to deal with the post implementation issues which may further evolve new systems.

4. BASED ON PRESENT SITUATION

Relevant information from different areas of Salt Lake City was collected for constructing database. After collecting information GIS application was implemented. By this way it can be established that there are several lacunas of existing SWM in Salt Lake which can be mitigated by implementing GIS/MIS based approach. Following are the different steps considered in this study:

4.1   Collection of Information from various areas of the Salt Lake City

Salt Lake Municipal Corporation is responsible for collection of solid waste which is produced day by day from different areas of Salt Lake. It is already stated that there are five sectors in Salt Lake. Each sector consists of number of blocks. Total numbers of blocks in Salt Lake are 78. There are several sources for solid waste generation in this city which are as follows:

    i)   Markets
    ii)   Play Ground/ Parks
    iii)   Domestic Buildings/ Houses
    iv)   Houses containing shops
    v)   Institutions
    vi)   Offices/Bhawans/Complex
    vii)   Shopping Malls
    viii)   Hospitals and
    ix)   Factories etc.

 The statistical information of producing solid waste (in kg) per day from different sectors is listed in Table 1:

Table: 1

Sector	House	Market	Play Ground	Park	Institution	Office	Mall	Bhawan/ Complex	Hospital	Factory	Total
1	47941	16200	6	20	421	859	2005	12562	750	0	80772
2	35936	10000	4	15	90	183	0	1655	405	0	48288
3	24272	6250	53	7	5047	612	502	13302	1000	0	51045
4	0	0	0	1400	0	0	0	0	0	0	1400
5	1936	2000	12	10	1785	6170	200	5360	0	1600	19073

By analyzing data of Table 1, it can be concluded that:
    a)   Garbage production from house is higher in Sector 1 among all sectors
    b)   As Sector 1 is rich in market thus production of garbage from this sector is higher than rest of area
    c)   Both Sector 1, Sector 3 and Sector 5 are rich in offices and complex, thus   production of garbage from this area is higher than rest of sectors
    d)   Numbers of factories are in Sector 5 and producing considerable amount of garbage

4.2 Garbage Collection Procedure

Salt Lake Municipal Corporation is responsible for collecting the garbage from different areas of Salt Lake. They collect this garbage in regular manner. Salt Lake is a planned city thus houses, shops, markets, offices, hospitals, factories – major sources of garbage producers are located at specific areas. There are numbers of big dust bins in several areas of the city and several blocks share each big dust bins. Garbage is accumulated in this bin from adjacent areas. In each block 4 sweepers are working and each of them wear blue dress with yellow colored helmet. Besides that 2 persons are involved for collecting garbage from door to door. In market area, extra 2 sweepers are provided. In Salt Lake area there is no open drainage system so sweepers are involving to sweep the road and collection the garbage and transfer the waste into the bins. The collection of waste from these dust bins is frequently

done where numbers of sweepers involve. The collected garbage is carried by small cart, tractors or trucks which are dedicated for collection purpose.

4.3   Transportation of garbage

Collected garbage is transported to the disposal areas in specific manner. It starts from small dumper and ends into big dust bins. Among the collected garbage, both degradable and non-degradable wastes are present. It is alarming that several plastic products are dumped into the dust bins. Several types of vehicles are used for transporting garbage to disposal sites which are as follows:

i)   Tri cycle cart
ii) Tractor
iii) Tipper Truck

6 tri cycle carts are provided in each block for collection of garbage from door to door. But in market area extra 2 tri cycle carts are provided. One tipper truck &one tractor are provided in each block. Tipper truck and tractor both are giving 4 trips from a block One truck can carry 65 bin and one tri cycle cart can carry 8 bins. 8 people are provided in the truck and 5 people are provided in the tractor. The tractors and dumpers carrying waste are not covered or partially covered during the journey and waste tends to spill on the roads. The loading and unloading of waste is done through manual as well as mechanical system.

4.4 Disposal of waste

Normally the collected garbage is disposed in specific site and garbage is recycled where it is possible. Though Salt Lake is a satellite township but all garbage is disposed into *Moller Verrie* area without treatment and recycling. So till now there is no recycling procedure of garbage according to the normal specification i.e. Municipal Solid Waste (Management & Handling) Rules 2000 of solid waste treatment.

5.   CONSTRUCTION OF MAPS BASED ON GIS & MIS DATA

A database was created containing several information like blocks wise quantity of garbage, location of markets, offices, institutions, hospitals along with longitudes and latitudes of dust bins. With the help of GIS logger we calculated the longitude and latitude of these locations. The map of Salt Lake was obtained from Google Map and saved in .tiff format. A Program was developed in C Language and MATLAB which was able to take the longitude and latitude information of dustbin as input and plotted this region as red colored spot on this map. This map is shown below:


Location of Waste Bins (Red Coloured)

Following table shows the block wise quantity of solid waste (in Kg):

BLOCK WISE QUANTITY OF SOLID WASTE

Sector	Block	House (In Kg)	Market (In Kg)	Play Ground (In Kg)	Park (In Kg)	Institution (In Kg)	Office (In Kg)	Shoping Mall (In Kg)	Hospital (In Kg)	Bhavan/Complex (In Kg)	Factory (In Kg)	Total (In Kg)
I	A Block	15,703	2000	1	1	235	213	0	0	2200		20,353
	B Block	16002	6200	2	5	30	172	400	0	0		22,811
	C Block	11268	2000	1	6	50	70	0	0	5832		19,227
	D Block	2708	2000	0	2	55	195	1600	750	1850		9160
	E Block	2260	4000	2	1	45	209	5	0	2600		9122
II	A Block	10584	2000	1	6	0	47	0	0	1500		14,138
	B Block	12700	2000	1	5	67	33	0	55	0		14,861
	C Block	9024	4000	1	2	23	67	0	150	0		13,267
	D Block	1908	0	0	1	0	20	0	0	80		2008
	E Block	1720	2000	1	1	0	17	0	200	75		4014
III	F Block	9044	2000	41	3	172	175	2	0	2885		14,322
	G Block	5880	2000	3	1	260	30	0	0	1400		9574
	H Block	5288	0	3	2	15	34	0	200	345		5887
	I Block	3932	2250	1	1	0	23	150	800	675		7832
	J Block					700						700
	K Block	208						350		3520		4078
	L Block					3900	350			750		5000
IV					1400							1400
V	A Block	500				220	385			1100		2205
	B Block					530	525			1360	200	2615
	D Block	388	2000	2			760			650	200	4000
	C Block					420	1450			650	450	2970
	E Block	960				445	1600			200		3205
	GM	88		5	10	70	1350			1400	200	3123
Total(Kg)		**110085**	**34450**	**75**	**1452**	**7342**	**7824**	**2707**	**2155**	**32879**	**1600**	**200578**

Another program was written in C Language and MATLAB which was able to construct waste generation map which is given below:
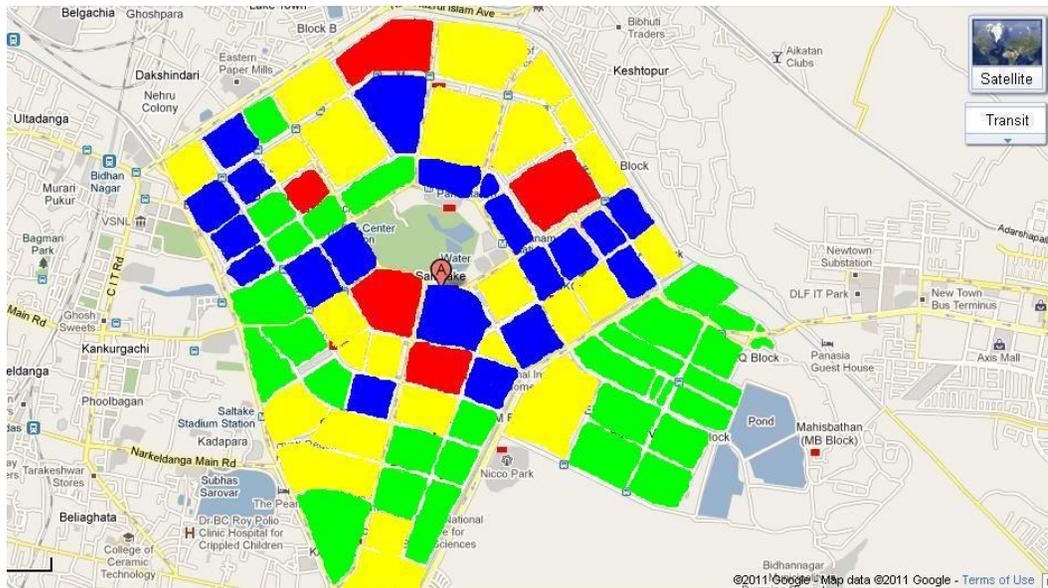
Waste Generation Map of Different Areas of Salt Lake City

Here following parameters were considered in this program:

Serial Number	Color Code	Significance
1	Green	0-1500 Kg Waste Produced Daily in this Block
2	Yellow	1501- 3000 Kg Waste Produced Daily in this Block
3	Blue	3001- 4500 Kg Waste Produced Daily in this Block
4	Red	>4500 Kg Waste Produced Daily in this Block

6. DISCUSSIONS
If both "Locations of Dustbin map" and "Waste Generation Map" may be compared then following may be concluded:
- **Waste bins are not properly distributed**: it is noted that in several areas of Salt Lake especially in eastern part, few numbers of dustbins are found.
- **Distance between waste bins varies in great extent**: it is found that generally in each block only one dustbin is present. The area of each block varies greatly. Thus in several cases it is found that the distance between waste bins located in adjacent blocks considerably large.
- **There is no proper justification regarding waste generation and number of waste bin in a particular area**: it is because several red colored area i.e. huge garbage production areas contain few numbers of waste bins.
- **For effective SWM, both GIS & MIS data should be implemented**: by applying this concept the waste generation map can be constructed which is essential for justifying existing waste bins locations and optimizing the garbage collection pathways.

7. CONCLUSIONS
In the conclusion it has been discussed about the reformation in the concepts of the data management and the analysis carried with the help of GIS. Once the waste management department is aware of the total function of the GIS system, it will get acquainted with its effectiveness. Then there will be an entire record of all the things related

to the waste management and suitable logistic management and spatial planning can be achieved. This can be done with the help of GIS analysis on the different layers for practical implementations. By applying the functions like overlaying, applying buffer for proximity analysis or by applying queries through a structured query language (SQL) the required information can be extracted.

- Demographic map can be used to know the more waste generating areas.
- The category of waste like domestic, industrial, commercial etc can be found out easily with the help of the land use map.
- Existing location of the waste bins and the street maps will provide the proximity of the bins to the waste collection service routes. In case of any inconveniency for the waste collecting crew the bins can be re located.
- A map showing the current waste generated and the waste generated in different wards, sectors and along the roads, streets and junctions.

These above enlisted points are said to be an important exercise to begin with. The points overall covers many waste management issues, but they are very generalize and require a lot of data and proper analysis using the GIS software. There will be a requirement to develop several models to apply all those points on the real time data.

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