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Integrated Solid Waste Management Model for Developing Country with Special Reference to Tezpur Municipal Area, India

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Abstract:
The state of solid waste management in most of the urban areas of developing countries is now a major social and environmental challenge with the explosion of Population and the pace urbanization. In India in particular, the combined influence of poverty, population growth and rapid urbanization has tended to worsen the situation. In response to the waste challenge many developed countries have embarked upon ambitious environmental reforms, recording remarkable advances in best practices and sustainable management of MSW. However, like many developing countries, India has faced many problems to manage the MSW in a sustainable manner. The study aims to carry out an analysis on the waste management practices and to develop a integrated waste management model for Tezpur municipal area and for the similar environment.

Keywords: *Solid Waste, Urbanization, Environment, Sustainable management*

1. Introduction

MSWM is a challenging problem for the developing countries like India where the trend of urbanization is very high. In India, the municipal bodies render the solid waste management services. Though it is an essential service, it is not attaining proper priority, which it deserves and services are poor. This has caused many problems in urban environment as well as to the public health in most of the Indian cities and towns.

Solid Waste Management is a vital, ongoing and large public service system, which needs to be efficiently provided to the community to maintain aesthetic and public health standards. Municipal agencies will have to plan and execute the system in keeping with increasing urban areas and population. The quantity of waste generated in India has increased considerably during the last three decades and that produces enormous challenges to the municipal bodies for their effective management and disposal. Like other towns and cities of the country in the state of Assam, the problem of solid waste becomes a serious one and needs extensive research for effective management of the wastes.

The city of eternal romance "Tezpur" is located in the North eastern part of India, in the states of Assam. The town is located on the northern bank of the mighty river Brahmaputra and almost at the heart of the Brahmaputra Valley. Tezpur is the head quarter of Sonitpur District and is considered as one of the most beautiful towns of Assam. Flourishing green valleys surrounded by hills of the majestic Himalayas as northern backdrop, lavish tea gardens and magnificent archaeological ruins contributes to make Tezpur a tourist delight. This beautiful town is now transforming to a garbage centre with the increasing volume of wastes and its impacts have been observed on the urban environment and public health. The present research aims to study the existing waste management mechanism and to design an Integrated Solid Waste Management model for sustainable management of wastes in Tezpur town.

2. Methodology

In order to achieve the objectives and to design the research paper the following research methodologies are followed:

2.1. Solid Waste Survey

It is essential to measure the quantum of generated waste to design an accurate management system. Hence, a pre-sort site assessment was carried out with the aim to determining the suitability of the site and facilities for waste categorization study. Information gathered during the pre-sort site assessment helps in designing the sampling procedures for the waste characterization study. Materials Classification categories were carried out by using the material classification format as given in Table 1.

Sl. no	Waste Types
1	Organic
2	Fine Earth
3	Demolition Debris
4	Plastic Materials, Polythene Bags, Thermocol etc.
5	Metals
6	Glass
7	Soiled Papers, Card Boards
8	Textiles
9	Miscellaneous

Table 1: Material Classification Format

After the completion of the site assessment waste characterization assessment was adopted. Characterization assessment study covered-

(i). Waste collection: To study the waste characterization, waste sample were collected from 10 numbers of community bins across the town and about 100 kilograms of wastes were collected.

(ii). Sorting Events: MSW samples collected from community bins were sorted, categorized, weighted and documented. Material based categorization approaches were adopted to categorize the samples.

Literature contains several methods for waste quantum and characterization study. This study adopted the weighting exercise method and the traditional and simpler material based classification approach developed by National Environmental Engineering Research Institute, Nagpur, India, for the measurement of waste quantum and component.

Weighting exercise was carried out to estimate the total volume of MSW generated in the town. To perform this activity the number of trips performed by all categories of vehicles were recorded for seven consecutive days. The record helps to determine the average number of trips performed by each category of vehicle/day and to estimate the total volume of wastes generated daily in the study area. In India, most of the municipality authorities adopted this method to estimate the volume of daily generated waste (Kumar, 2009). The waste generated by each person/day was estimated by dividing the total volume of wastes generated daily by total estimated population of the study area.

About 100 kg of waste samples were collected from 10 community bins located in different localities across the town and mixed thoroughly. The mixtures were finally reduced to 12.5 kilogram by Quartering Techniques. In this technique, the total collected wastes were divided into four equal parts and waste from two diagonally opposite portion were taken and mixed. The other two portions were discarded. Similar procedures were repeated until a waste sample of approximately 12.5 kilograms in weight. From this 12.5-kilogram sample, wastes were categorized into 9 pre designed categories – organic, silt, demolition debris, plastics, paper, metal, glass and miscellaneous wastes. Segregated components were weighed to determine their weights as a percentage of the total weight of sample. Weighting exercise method is considered to be the best method to know the waste characteristics as far as the Indian conditions are concerned (Kumar, 2009).

2.2. Study Region

The absolute location of the town is $26^0 38^/$ N latitude and $97^0 48^/$ E longitude. The town is about 330 feet above the MSL. In the year 1894, the town was declared as municipal town with 2.75 square kilometres of area. At present, the town is now extended over an area of 7.10 square kilometres and the population size was estimated at 1,00,477 in 2014. The municipal area is now divided into 19 numbers of municipal wards for the smooth functioning of the administrative and other activities. The physiographic characteristics of the area is slightly undulating in nature Presence of few out crops of the Achaean ages along the southern margins of the region makes the surface topography uneven in nature. Being a part of the Brahmaputra Valley the region experiences typical tropical monsoon type of climate with hot and humid summer months and cool and dry winter months..

2.3. Estimation of Waste Quantum in Tezpur

Table 2 presented the result of the exercise performed in the study area. The number of trips made by different vehicles for seven consecutive days and the approximate amount of waste carried to the disposal site is shown in the Table 2. From the average daily number of trips performed by each category of vehicles and the approximate load carried by these vehicles, the total quantum of MSW generated in the town was estimated. Thus, the average amount of wastes was estimated at 27.70 tones with an average amount of 0.275 kg/person/day.

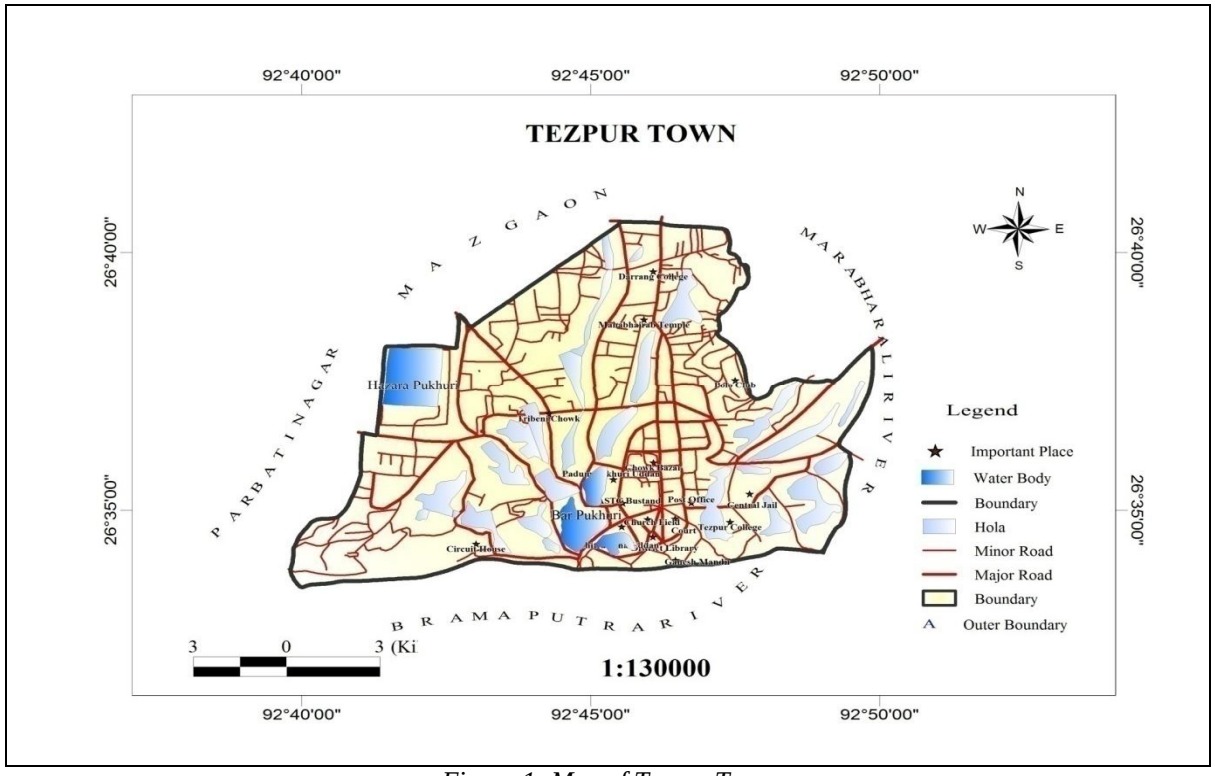

Figure 1: Map of Tezpur Town

Vehicle Types	Load Carrying capacity in (Tones)	No of vehicle in operation	Approximate average amount of load carried by each vehicle per trip	Average number of trips performed daily	Total no.of trips performed by the vehicles	Average Approximate quantity of waste carried daily in (Tones)	Total Number of Trips Performed in a week	Approximate quantum of waste carried weekly (Tones)
Mini Truck	6	1	3.88	2	2	7.71	14	7.71
Tractor Trailer	4	2	2.90	3	6	17.42	42	122
Dumper Placer	2	1	1	2	2	2.57	14	18
Total	12	4			10	27.70	70	194

Table 2: Quantum of MSW generated and number of trips conducted by the vehicles in Tezpur

Average quantity of garbage generated by each person

$$= \frac{Total\ amount\ of\ waste\ generated}{Total\ estimated\ \ population}$$

$$= \frac{27700\ KG}{100477}$$

= 0.275 kg /person / day

2.4. Waste Composition Analysis in Tezpur Town

Table -3 presents the percentage of components of MSW collected and analysed in the study area. Table- 3 shows the percentage of organic components in the waste stream as 72%. Hot and very humid climatic conditions are considered as important causes behind the high percentage share of organic wastes in the waste stream. It was observed that, a large volume of organic wastes were generated from the residential areas in the form of kitchen waste, garden waste and fruit waste. Wastes sources like lawns, parks, playgrounds and institutional campuses have also contributed sizeable volume of organic wastes in the waste stream. Moreover, fruits and vegetable residues from the both wholesale and retail market areas, leftover foods from the hotels, restaurants, hostels, community halls etc. have increased the percentage of organic waste to such an extent.

The quantity of silt, clay and fine earth was found high about 9% in the total waste volume. Such types of wastes were mainly derived from covered and open drains. During the rainy season from the un-surfaced roads a large quantum of silt and sands accumulates in the drains and contributes a sizable share to the total volume such wastes. The percentages of demolition debris were estimated at 3% of the total volume of MSW and such types of wastes were originated from the construction and demolition sites. The pace of urban growth has increased the percentage of such kind of waste in the waste stream.

Sl.no	**Waste Types**	**Percentage of Waste Types**
1	Organic	72.00
2	Fine Earth	9.00
3	Demolition Debris	3.00
4	Plastic Materials, Polythene Bags, Thermocol etc.	8.00
5	Metals	0.30
6	Glass	1.00
7	Soiled Papers, Card Boards	2.50
8	Textiles	0.20
9	Miscellaneous	4.00
TOTAL		**100.00**

Table 3: Percentage of components in the waste stream in Tezpur municipal area

Dense plastics, polythene bags, plastic packets were found in large quantities in the waste stream. Use of polythene bags not only increases their volume but is also responsible for serious environmental problems in the town. The percentage of soiled paper, card boards, thermocols, used tyres and synthetic materials were also found high in the waste stream and their percentage shares were estimated at 8%. But the quantity of metals, cans, news papers were found substantially low as such wastes have either picked up from the community bins and open dumping sites or collected directly from the households by the rag–pickers for recycling purposes. Fig-2 shows the percentage share of various components found in the waste stream in Tezpur municipal area.

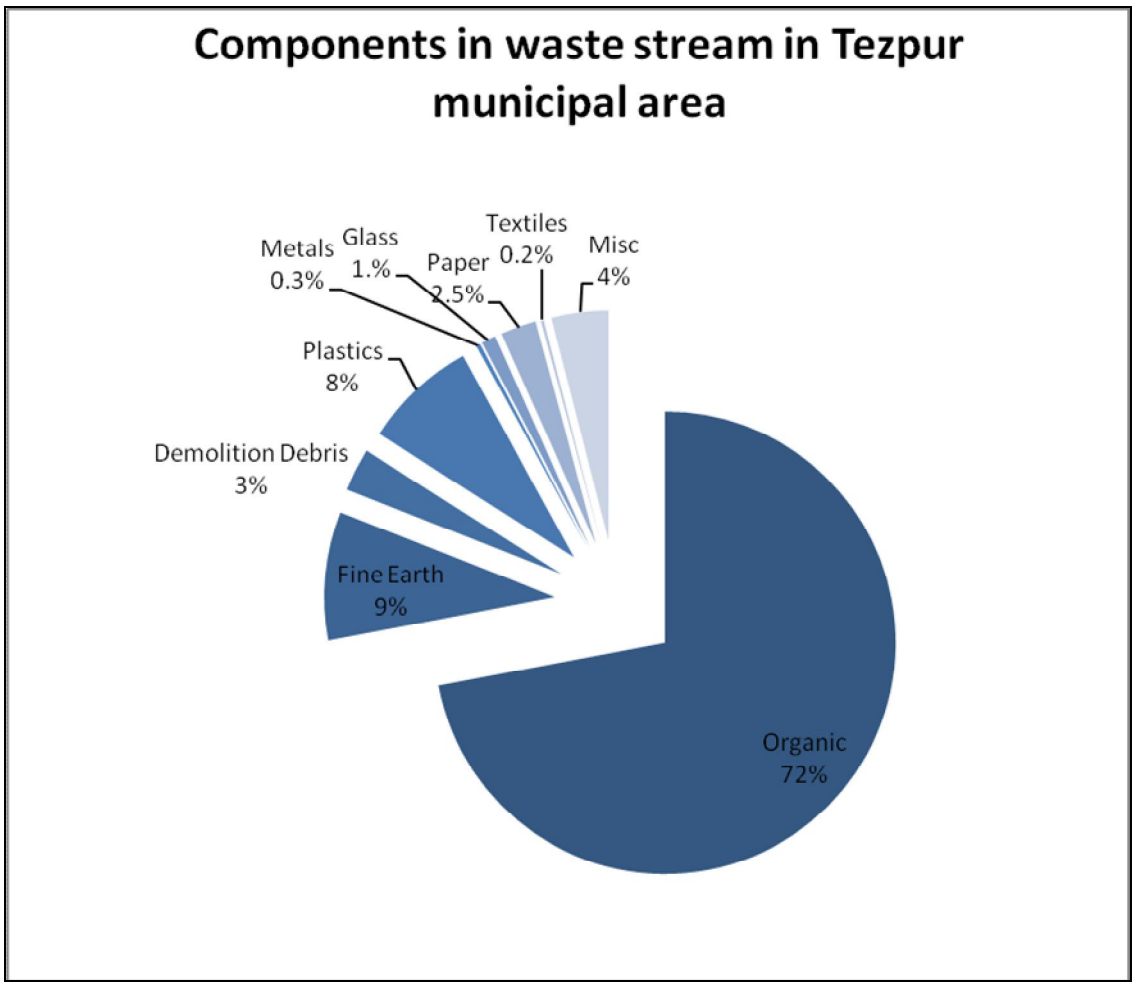

Figure 2: Components of waste stream in Tezpur municipal area.

2.5. Present waste management scenario

In Tezpur municipal area about 27.70 tons of wastes were generated daily and to store the wastes only 35 numbers of community bins have been used. As the numbers of community bins were few and distributed haphazardly without any planning, residents have no other alternatives rather than to deposit the wastes along the road sides and in the open drains.

The urban local body has used RCC bins and metallic containers to store the wastes and 132 numbers of workers were engaged to handle the waste management task. The sweeping crew collects the wastes from road sides and deposit in the nearby community bins by using tricycles. Door to door waste collection system has not yet been started in the municipal area.

To transfer the wastes two numbers of tractor trailers, a mini truck and a dumper placer were used. Every day, the tractor trailers performed 3 trips each while the mini truck and the dumper placer only 2 trip each. The collected wastes were carried in open trailers and trucks for about 4 Kilometres to the final disposal site located at Marabharali. The collection drive starts at 7 A.M and continued till 2 P.M in the afternoon under the supervision of four officials of the engineering divisions of the Urban Local Authority maintaining a pre-designed schedule.

Collected wastes were finally disposed by simply dumping and land-filling processes. The dumping site is located about 4 Kilometre away from the town on the bank of the Marabharali. The final waste dumping site is about 0.033 square Kilometres in area. Open air burning and unscientific land filling of wastes not only causes air pollution but also contamination of ground and surface water in the nearby locality.

2.6. Integrated solid waste management system

Integrated waste management is concerned with synthesizing a range of different option to deliver an environmentally and economically sustainable system for a particular area (White et al, 1995). Hence, it describe an approach in which decisions on waste management takes account of different waste streams, collection, treatment and disposal methods, environmental benefits, economic optimisation and social acceptability. To integrate a solid waste programme within a community, the programme should address the needs of the community as a whole. In other words waste generated from individual houses, apartments, public places, business, and industries located within a community should be taken into consideration for efficient management. Enough flexibility should be built into a programme so that it can protect the environment. Willing participation of the community as a whole in reducing waste is

essential. Thus, apart from management practices, due consideration should be given to educating the source reduction concept coupled with proper storage, effective collection, transfer, treatment and disposal of waste.

2.7. Planning integrated solid waste management

To ensure better human health and safety there will be a need of effective solid waste management system for the urban areas. The system needs to be safe for workers and public health. Besides these requisites, the system must be environmentally sustainable and economically feasible. An economically and environmentally sustainable solid waste management system is effective if it follows an integrated approach (Ramachandran, 2008). The planning of integrated solid waste management system has been explained below in a case study for Tezpur Town.

1. Reduction of waste at source with the active participation of the community. Wastes can be reduced by changing the consumption pattern, use of recyclable materials, practice of waste segregation and refusing the use of polythene bags etc. About 20% reduction in waste generation is possible through simple housekeeping measures that require no marginal investment (Ramachandra, 2008).
2. There are considerable benefits of increasing solid waste recycling and reuse. Source separation and recycling of waste reduces the volume of the waste considerably. Promoting recycling as an alternative to the existing forms of waste disposal may be economically gainful. Further, thousands of poor people are directly or indirectly participating in waste collection and recycling to support their families.
3. Composting seems to be a very effective measure of waste disposal in the study area as organic waste constitutes about 72% of the wastes stream. Composting is a form of source reduction or waste prevention as the materials are completely diverted from the disposal facilities and require no management or transportation. Diverting such materials from the waste stream frees up dumping space or the materials that cannot be compost.

i. Practice of dumping of waste along the final disposal site is found to be unscientific and highly vulnerable to environment and public health. Sanitary land fill not only reduces the risk to the environment and public health but also proper use of land fill site to the fullest extent. Therefore, adoption of sanitary land filling will be a better option for final disposal of wastes in the study area.

ii. Community participation is essential for smooth and efficient operation of solid waste management system. Performances of such system depend on the meaningful participation of individuals, communities and institutions, producers, NGOs and government. The key element of the community participation is involvement of the community in the decision and implementation process. Therefore, a consistent and ongoing educational programme is necessary for the success of the waste management system.

2.8. Proposed ISWM scheme for Tezpur

The ISWM scheme for Tezpur municipal area have been designed to minimize the initial generation of the wastes through source reduction, then through reusing and recycling to further reduce the volume of the material being sent to landfill sites for final disposal. Efficient management of wastes requires collection of up- to- date information for corrective measures as well as future planning. Integration and assimilation of information from various sources and levels also have been considered important in ISWM. Thus, the strategic approaches for ISWM involve integration of available data, guidelines and framework to eliminate the constraints. The main objective here is to proper storage, effective collection, transfer, processing and disposal of wastes according to the constituents present in the waste stream in a sustainable manner with the participation of the community. To maintain a healthy environment, the ULB has to adopt this approach and set goals to reduce the amount of solid waste in a cost effective manner.

2.9. Focus of the ISWM Scheme

1. Segregation of wastes at source especially the household wastes through active participation of community and in separate containers and regular collection of wastes by using separate fuel efficient vehicles according to nature of the wastes. Use of compactor makes the collection drive more efficient and cost effective.
2. Improve community bins, storage containers for the storage of biodegradable and wet wastes and containers should be placed scientifically using GIS and GPS.
3. Adequate training to all the levels of staff engaged in solid waste management to handle respective functional aspects like collection, generation, storage, segregation of waste etc. and medical check-ups for municipal workers and rag pickers should be mandatory at regular interval.
4. Establishment of some transfer station for smooth operation of the SWM system at some suitable locations.

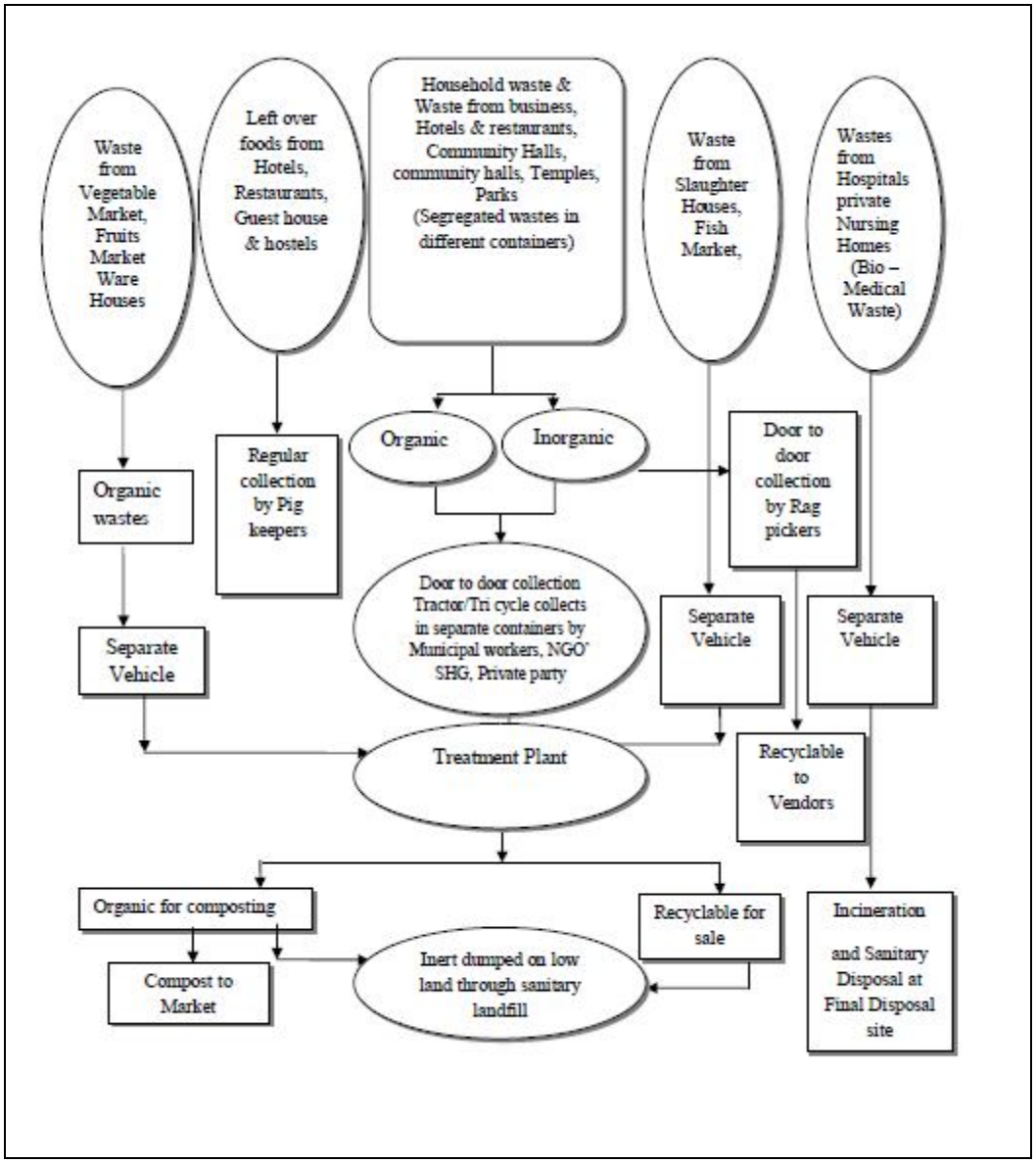

Figure 3: ISWM Model

5. Composting should be done with the help of technological experts and o handle the bulk of waste generated everyday sanitary landfill site have to be set up to dispose off the rejects after composting.
6. Promotion of public participation in the SWM scheme and constitution of citizen forum in each municipal ward involving local people.
7. Developing public –private partnerships leading to privatization of some aspects of garbage collection, recovery and disposal.
8. To tackle various issues such as road sweeping, open dump, open burning, garbage collection, disposal etc. regular monitoring is necessary.
9. Garbage tax should be levied against large and small generators for the disposal of Wastes.
10. Administrative restructuring of the ULB to discharge more efficiency and specific responsibilities. This requires structural changes within administration aimed at decentralizing authority and responsibilities. This also includes periodic meetings among the staff and between the executives and elected wing of the board.
11. Encouraging involvement of local NGO's in working on various environmental awareness programmes and areas related to waste management including the public about the importance and necessity of better waste management.
12. Privatize solid waste management facilities or contract for waste disposal services, including recycling.

3. Conclusion

Rapid population growth and unplanned urbanization led to the tremendous increase in the amounts of municipal solid waste in many cities and towns of the developing countries like India. Mismanagement of wastes not only causes serious environmental problems but also risks to public health. Therefore, there is a shift from the traditional solid waste management options to more integrated solid

waste management approaches. However, the lack of planning, adequate resources, administrative inefficiency is posing a serious obstacle to implement the ISWM approach.

Waste management system in Tezpur is traditional and needs up gradation in the areas of storage, collection, transfer, processing and disposal. Financial hurdles and lack of co-ordination and co- operation between the concerned authority and the public has created bottlenecks in improving its efficiency. The potentiality of the community participation in the waste management system has to be given more and more emphasis for smooth management of the system along with the adoption of latest spatial analytical technologies such as GPS-GIS system. However, government initiative is always necessary to make the system successful. Waste recycling can be promoted through consumer campaigns that will encourage citizen to co-operate in waste separation and to purchase recycled products. In the same time ULB should encourage composting of wastes which will not only reduce the volume of waste to dispose but also maintain a healthy environment and low risks to public health. Finally, proper monitoring of the system in every steps is utmost important for smooth functioning of the system.

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