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Design of an Integrated Solid Waste Management Mechanism: A Model Design for Tezpur Municipal Area, Assam

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Abstract: *Solid waste management has become a very complex and challenging task for the local self governments due to financial and organizational constraints. Therefore, in countries like India much of these wastes, especially hazardous, bio-medical and non degradable waste, are inadequately managed and very often, causing serious environmental and health related problems. The main focus of the research work therefore, is to review the existing solid waste management scheme and to design a more effective and integrated solid waste management mechanism through the active participation of the community for the study area and to work in similar condition.*

Keywords*: Integrated solid waste mechanism, hazardous, bio- medical, non-degradable.*

I. Introduction

Rapid urbanization is changing the nature of solid waste management from a low priority, localized issue to an internationally pervasive social problem. 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

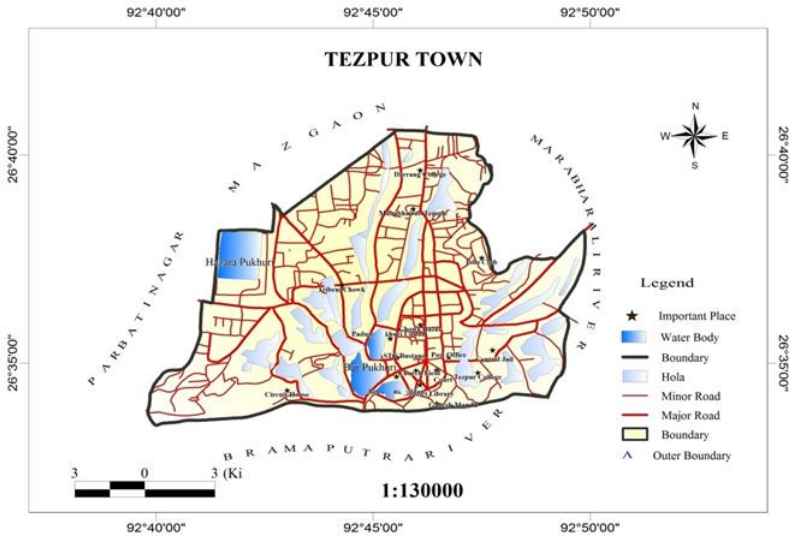

Figure 1 : Map of Study Aea

the country, in Tezpur, 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 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 have contributed 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.

II. Methodology

Literature review

An extensive literature review was done on the subject. Books, journals, abstract dailies articles, unpublished works were reviewed.

Solid waste survey

It is essential to measure the quantum of generated waste to design an accurate management system. Hence, an accurate solid waste survey was made in the study area to estimate the generated waste and their characteristics. Materials Classification Categories were carried out by using the material classification format as given in Table 1

Table 1: Material Classification Format

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

A pre-sort site assessment was carried out with the aim at determining the suitability of the site facilities for waste categorization study. Information gathered during the pre- sort site assessment helped in design of sampling procedures for the waste characterization study.

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

i) Sampling and Sorting Events: MSW samples collected from ten numbers of community bins were sorted, categorized, weighted and documented. Samples were used to categorize on material based categorization approach.
ii) Frequency of Sampling: To examine the nature of the waste, physical analysis has been conducted after collecting the samples from 10 community bins across the town.

iii) Waste Generation: To study the waste composition, samples of the waste have been collected from the community bins across the town.

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 has been 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 has been recorded for seven consecutive days. The records have help to determine the average number of trips performed by each category of vehicle/day. The daily waste quantity has computed and waste generation in kg/capita/day has been estimated by dividing the total generated waste by total estimated population of the town. In India, most of the municipality authorities adopted the same method to estimate the volume of daily collected waste (Kumar, 2009).

About 100 kg of sample waste were collected from 10 community bins located in different localities across the town and mixed thoroughly. The mixtures have been finally reduced to 12.5 kilogram by Quartering Techniques. In this technique, the total collected waste has been divided into four equal parts and waste from two diagonally opposite portion has been taken and mixed. The other two portions have been discarded. Similar procedures have been repeated until a waste sample of approximately 12.5 kilograms in weight. From this 12.5-kilogram sample, using the pre designed 9 categories – organic, silt, demolition debris, plastics, paper, metal,

glass and miscellaneous wastes were segregated. Segregated components were again weighed to determine their weights as a percentage of the total weight of sample. This method is considered to be the best method to know the waste characteristics as far as the Indian conditions are concerned (Kumar, 2009).

Use of Interview schedules

Interview schedules were designed to collect information directly from the respondents. In all the cases it was ensured that the respondents were either residents of Tezpur town or those who work in the town. In order to determine a suitable sample size, sample size calculator provided by Research Information (2008) was utilised. By assuming the population of the town 1, 00,000 and a confidence level of 95% (0.05), a sample size of 380 was considered.

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 has extended over an area of 7.10 square kilometres and the population size was estimated at 1, 00,477 in 2011. Tezpur Municipal Board has divided the town into 19 numbers of municipal wards for the smooth functioning of the administrative and other activities. With slightly undulating landform characteristics the region experiences typical tropical monsoon type of climate. The climate is characterized with hot and very humid summer season and cool and dry winter season.

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 has 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 were estimated. Thus, the average amounts of wastes were estimated at 27.70 tones with an average amount of 0.275 kg/person/day.

Table 2: Quantum of MSW Generated and Number of Trips Conducted by the Vehicles in Tezpur

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

Average quantity of garbage generated at per capita level

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

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

= 0.275 kg /person / day

Waste Composition Analysis in Tezpur Town

The waste stored in the community bins and in open dump sites were found different in their physical characteristics such as size, structure, texture, hardness, softness, smoothness and chemical properties. To study the physical characteristics and composition of MSW in the town, samples of the MSW were collected from the community bins and open dumping sites from the ten selected localities. About 100 kg of wastes, 10 kg from each localities were collected and through quartering technique reduced to 12.5 kg and segregated on the basis of physical characteristics and estimated the percentage share of each group of components.

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 condition has considered as one of the causes behind the high percentage share of organic wastes in the waste

stream. A large volume of organic waste were also generated from the residential areas in the form of kitchen waste, garden waste and fruit waste along with the waste from the lawns, parks, playgrounds and institutional campuses. Moreover, fruits and vegetable residues from the both wholesale and retail market areas, leftover foods from the hotels, restaurants, hostels, public functions, garden waste from the parks, institutional campus, government and private offices; have enhanced the quantity of organic waste to such an extent.

Table 3 : Percentage of Different Components in the Waste Stream in Tezpur during

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**

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

Dense plastics, polythene bags, plastic packets were also found in large quantities in the waste stream. Use of polythene bags has not only increased their volume but also responsible for serious environmental problems in the town. The percentage of soiled paper, card boards, thermocols and synthetic materials were also found high in the waste stream and the percentage share was estimated at 8%. But the quantity of metals, cans, news papers were also found substantially low as such wastes were collected by the rag–pickers for recycling purpose. The percentage share of various components in waste stream has shown in Figure 2.

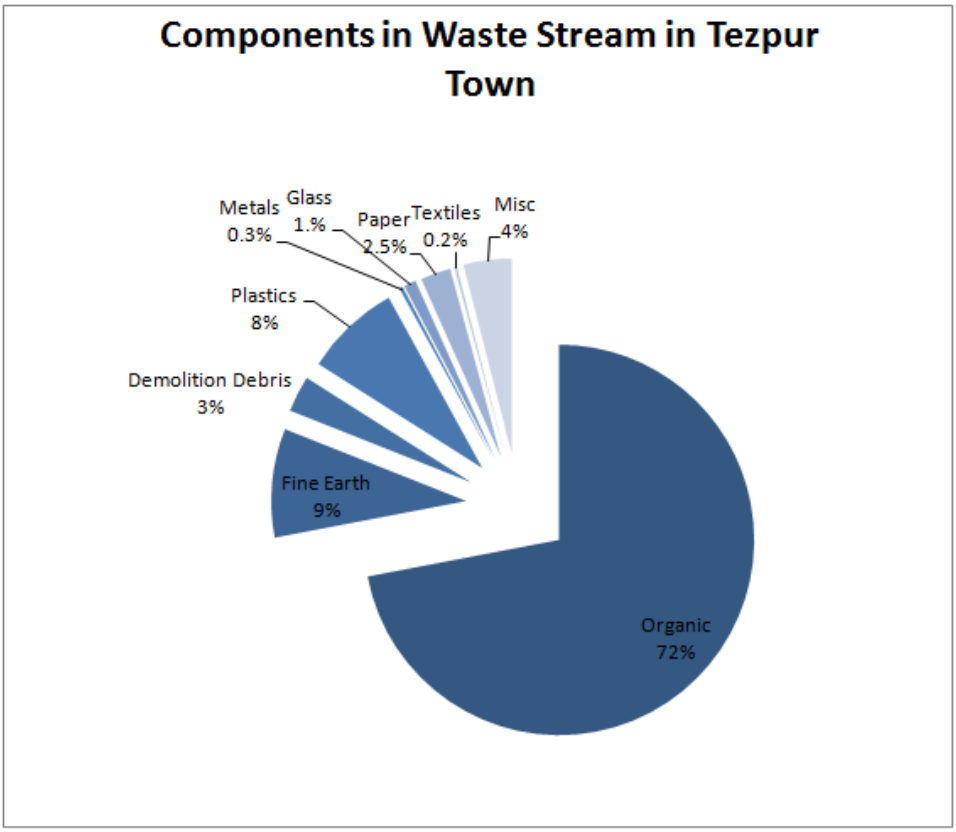

Figure 2: Components of Waste Stream in Tezpur Town

Community Participation in Waste Management

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. Involvement of the community in the waste management programme requires a significant educational effort. An ineffective and imperfect education programme may confuse the public and reducing the public confidence and inviting hostility towards the programme. A consistent and ongoing educational programme is necessary for the success of the waste management programme. Only a successful public education programme can secure public involvement and participation in the community waste management programme, right from the decision making to the successful implementation. An effective solid waste management education programme leads people through six stages like awareness, interest, evaluation, trial, adoption and maintenance (Sashikumar and Gopikrishna, 2009).

In Tezpur town, all the responsibility related to the waste management is assigned to the Tezpur Municipal Board. But, services provided by the municipal authority have been found insufficient and inadequate to manage the MSW in a sustainable manner. It is not only because of organizational and infrastructural problems, but also due to lack of public involvement in the existing waste management mechanism. Dumping and burning of waste on the road sides, open drains, misuse of community bins were some common activities performed by the residents in every locality in the town. Lack of knowledge and responsibility towards the waste management mechanism may lead to such nuisance activities with the MSW. Therefore, awareness campaigning on the role and responsibility of the publics in waste management are considered to be very much essential.

Assessment of Respondents' Understandings of MSWM Related Subjects

Assessment of respondents understanding of MSWM related subjects are very much essential for sustainable management of MSW and to design an integrated waste management model. In this account an attempt was made to assess the responses of the respondents towards the existing management system. A series of questions were asked to the respondents during the survey about the existing waste management mechanism in the town as well as its impact on environment and public health. Respondents responses on various aspects of waste management like existing waste management, waste collection,Public participation in waste management and compost from waste,were recorded and analysed systematically. Respondents' responses are considered to be very important for designing an Integrated Solid Waste Management model.

Assessment of Respondents' Knowledge on Existing Waste Management System

Table-4 presents the respondents' levels of understanding of existing waste management system in Tezpur town. Respondents were asked question about their knowledge on existing waste management mechanism, their satisfaction, and introduction of private company in the waste management system.

On these questions of the total, about 32% responses were found positive on the other hand about 60% of the responses were found negative about their knowledge on existing waste management system in the town. About 8% of the respondents were not sure of their responses to the question. This might also indicate that respondents had little understanding of existing waste management system. Overall, nearly 68% of surveyed population had little or no understanding of existing waste management mechanism in the town. During the study it was observed that majority of the respondents have no knowledge regarding waste management system.

Assessment of Respondents' Responses on Public Participation in Waste Management

The responses of the respondents on the issue, the level of understanding on public participation in waste management mechanism in the town have shown in the Table-4. Respondents were asked question on the issue to know the role of public participation in the existing waste management system in the town and their opinion in this regards.

Regarding the issue about 28% of the total respondents said their understandings of the knowledge of community participation in waste management to be excellent. On the other hand about 50 % respondents said their understanding of the knowledge of community participation in waste management to be very poor. About 22% of the respondents were not sure of their responses to the question. Overall, nearly 72% of the surveyed population have no or very little knowledge about community participation in waste management system.

Assessment of Respondents' Responses on compost from Waste

Variations in the responses were also observed when respondents were asked about transformation of waste to compost. On the question of the total about 36% respondents responded positively while 57% respondents responded negatively and rest 7% respondent were not sure of their responses to the question. Overall, nearly 64% of population had little or no understanding of compost from the waste.

Table-4 Respondents Responses about MSWM in Tezpur

Municipal wards	Knowledge of existing MSWM system			Knowledge of Public participation			Knowledge on Compost from Waste		
	Good %	Poor %	Not Sure %	Good %	Poor %	Not Sure %	Good %	Poor %	Not Sure %
1	30	60	10	30	40	30	20	60	20
2	30	70	--	40	30	30	30	50	20
3	40	50	10	40	40	20	50	50	-
4	40	40	20	50	30	20	50	40	10
5	30	70	--	20	60	20	70	30	-
6	40	50	10	20	60	20	30	70	-
7	50	40	10	40	50	10	10	80	10
8	30	70	--	20	60	20	10	80	10
9	50	40	10	20	50	30	10	90	-
10	20	70	10	20	40	40	70	20	10
11	10	80	10	20	60	20	20	80	-
12	20	80	--	30	60	10	60	20	20
13	20	70	10	20	60	20	40	60	-
14	10	90	--	20	70	10	30	70	-
15	20	70	10	40	40	20	30	70	-
16	10	80	10	20	60	20	10	90	-
17	60	40	--	40	40	20	70	20	10-
18	60	30	10	20	60	20	30	70	-
19	40	40	20	20	50	30	40	40	20
Avg	**32.57**	**60.54**	**7.89**	**27.89**	**50.54**	**21.57**	**35.78**	**57.36**	**6.84**

Integrated solid waste management system

Integrated waste management is concerned with synthesising a range of different option to deliver an environmentally and economically sustainable system for a particular area(White et al, 1995).Hence, it 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 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.

Proposed ISWM scheme for Tezpur

The ISWM scheme for Tezpur municipal area is 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 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.

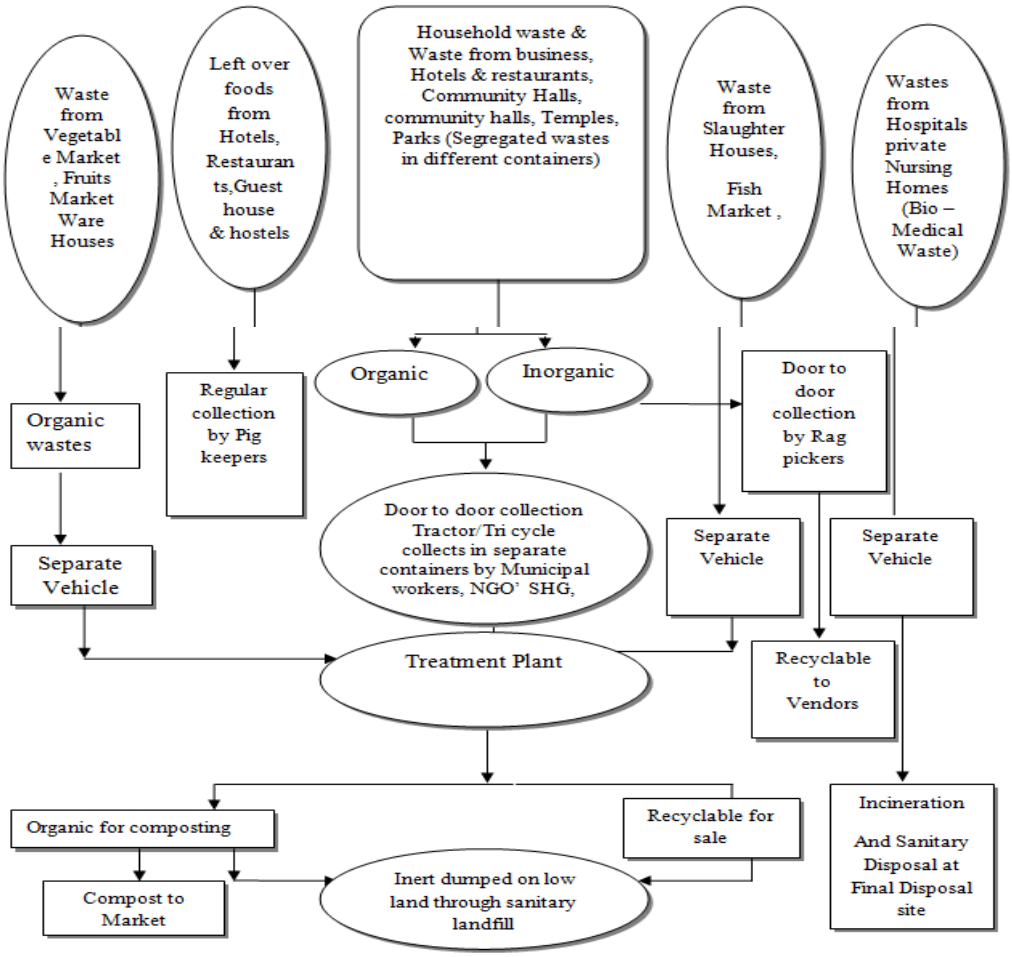

Figure 3 : ISWM Model for Tezpur Town

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 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.
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 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 local 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.

III. 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 upgradation 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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