Chapter 6
DISCUSSIONS
Chapter VI
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Kumar et al. (2009) pointed out that the municipal solid waste management in Indian cities has not been planned rationally due to non-availability of authentic or relevant information on waste generation and their characterization. Considering this statement, importance was given to generate baseline data and accordingly, investigation was made for collection of detailed information regarding solid waste generation in Guwahati city as per the methodology followed by the Guwahati Municipal Corporation. It was realized that only source specific characterization and quantification can give a clear picture of different types of solid waste generated in the city which is very much essential for formulating a rational and successful management plan of solid waste in the city. Therefore, an attempt has been made on assessment of source specific characterization and quantification of solid waste in Guwahati city.

Investigation was also performed for the study on the present practices of solid waste disposal and management and accordingly identified the associated problems. Under this background thorough study was made on the present practices of solid waste management to find out some ways of sustainable solid waste management practices in Guwahati, under ‘waste to wealth concept’.

6.1 Generation of Solid Waste in Guwahati

Proper identification of different sources of solid waste generation is essential to ascertain the total generation of solid waste which is almost similar in all urban environment in India. Further, sources are classified as regular and occasional source. Regular solid waste generating sources are Households, Commercial areas, Market places, Hotels, Restaurants, Hospitals and Nursing homes, Educational institutes, Cinema halls, Offices, Railway stations, Bus stations, Industries, Street sweeping & Drain cleaning, floating population and different other sources. On the other hand occasional sources are ‘Bihu’, ‘Durga Puja’, ‘Kali Puja’, ‘Idd’, ‘Book fair’, ‘Trade fair’, ‘Expo’ and different other identified occasional sources.
Among the regular sources, households generate highest amount of solid waste. The average per capita generation of household waste worked out to be 0.173 gm/day, out of which 73.96% was organic followed by paper 15.35%, plastic 2.54%, glass 0.83%, metal 2.41%, rubbish 1.23% and others 3.70%. Organic waste was also found to be more than the other types of waste in Market places, Hotel, Restaurants, Hospital and Nursing Homes, Educational Institutes, Railway stations and in Occasional sources. The organic waste has significant seasonal variation. Garden waste was highest during the month of July-September (monsoon-summer season) and lowest in January-March (pre monsoon-winter season). On the other hand, the amount of vegetables and fruit peels was found to be the highest in January-March (pre-monsoon-winter season) and lowest in April-June (pre monsoon-summer season). Whereas it was revealed that generation of kitchen waste was highest in January-March (pre monsoon-winter season) and lowest in July-September (monsoon-summer season).

Generation rate of paper was higher in commercial establishments and Offices, whereas plastic was higher in Cinema halls and Bus stations. Waste metal was higher in industries. On the other hand, street sweeping and drain cleaning activities generated more different other waste, chiefly huge quantity of sand and soil. Occasional sources generated significant amount of solid waste and as per the estimation average generation was 19.75tons/day.

Out of the total generating sources, household generating the highest amount of waste (45.91%) followed by Commercial Establishments (14.60%), Street Sweeping & Drain Cleaning (12.38%), Educational Institutions (5.93%), Occasional Sources (5.09%), Markets (4.38%), different Other Sources (3.98%), Restaurants (2.42%), Offices (1.38%), Hospitals & Nursing Homes (1.24%), Industries (0.90%), Hotels (0.69%), Railway Stations (0.61%), Long Distance Bus Stations (0.28%) and Cinema Halls (0.16%). Characterisation of the waste revealed that out of the total solid waste generation in Guwahati City, organic waste contributes 55% followed by paper 16.42%, others 11.25%, plastic 5.45%, rubbish 3%, glass 2.21% and metal 2.13%. As on 2008, total generation of solid waste in the city was 387.7 tons/day having per capita generation of 377 gm/day. As the population in the city is increasing day by day, generation of solid waste in the city is also expecting to increase. Current rate of growth of population in Guwahati is 3% per year. Moreover, due to the rapid increasing living
standard of Guwahati City, complexity and amount of per capita generation of solid waste is increasing day by day.

6.2 Existing Practices of Solid Waste Management in Guwahati

In the present scenario, the entire responsibility of solid waste management of Guwahati City is vested to Guwahati Waste Management Company Private Limited (GWMCPL) which is a joint venture of Guwahati Municipal Corporation and Ramky Enviro Engineers, Hyderabad. In this respect Govt. of Assam allotted 120 bighas of land at West Boragaon and additional 50 bighas of land are also sanctioned for solid waste management plant at Boragaon. Govt. of Assam has given the contract of solid waste management project for initially twenty years to ‘Ramky Enviro Engineers’ through an ‘International Biding System’ under the Jawaharlal Nehru National Urban Renewal Mission.

Presently, GWMCPL is conducting the following activities of solid waste management --

6.2.1 Primary Collection

For this activity ‘Ramky Enviro Engineers’ has engaged 17 Nongovernmental Organisations (NGOs) on contractual basis. NGOs are responsible for door to door collection of solid waste from their generating sources including households, commercial establishments, markets, hotels and restaurants, etc. and for the disposal of the collected solid waste in MS (metal surfaced) street bins well distributed in the city. Different kinds of vehicles are used in the process of door to door collection. As of now, 220 nos. of ‘Try Cycles’ and 100 nos. of ‘Push Cart’ are used for this purpose. The total number of MS bins kept on roadside are 360 and the solid waste collected in these bins are transported by 50 nos. of ‘Hydraulic Auto Tippers’.

6.2.2 Secondary Collection

Secondary collections are jointly conducted by Guwahati Municipal Corporation and Ramky Enviro Engineers. In this process of collection, 22 nos. of ‘Twin Bin Dumper Placer Vehicles’ are used for lifting and transporting the garbage loaded MS bins for the disposal of the garbage at West Bora Gaon land fill site. Moreover,
additional forces are regularly enacted by Guwahati Municipal Corporation for lifting of additional amount of waste from ‘road-side’, open public places, and lifting of rubbish and dead animals which are disposed in the land fill site. Rubbish is often tried to reuse for different purposes. Recently GWMCPL has plied two solid waste compactors for the collection of excess amount of solid waste.

6.2.3 Road Sweeping and Drain Cleaning

Guwahati Municipal Corporation is engaging 300 sweepers for street sweeping of all the main roads of Guwahati and 400 persons are engaged for drain cleaning activities in all the drains of main roads and by-lanes. Street sweeping activities are performed on daily basis, whereas drain cleaning activities are conducted as per requirement. Finally all the wastes are lifted to the land fill site of ‘West Bora Gaon’.

6.2.4 Production of Compost

‘Ramky Enviro Engineers’ has constructed a compost plant at Boragaon for biodegradable solid waste having a capacity of 50 tpd (tons/day). During field investigation, it was observed that plastics are mixed with the decayed biodegradable solid waste which is difficult to segregate by the machineries. For this reason, some amount of plastic residue always remains in the compost produced in the plant.

6.2.5 Sanitary land filling

Finally, all the collected non-recyclable non-biodegradable solid waste along with the road sweeping and drain cleaning waste are collectively dumped in the land fill site of West Bora Gaon.

6.2.6 Segregation by the Rag pickers

As per the assessment, there are 743 nos. of rag pickers engaged themselves in segregating recyclable solid waste from the total disposed waste. Rag pickers are also involving themselves for the cleaning of disposed MS bins in search of recyclable waste materials.
6.3 Problems with the Existing Solid Waste Management Practices in Guwahati

Guwahati Waste Management Company Limited (GWMCPL) does not have an effective and sustainable solid waste management plan. In the present management practices, there is no any system of source segregation of biodegradable and non-biodegradable solid waste. The health and environmental aspects as per the MSW Rules, 2000 are also not integrated in the waste collection and disposal systems. Though door to door primary collection system is officially made available for one lakh households of the city, in reality it is hardly covering 10% of the households which is the main reason of solid waste problem in Guwahati City. Moreover, the composite garbage including plastic left at the street corners, various public places, roadsides, street bins and drains etc. starkly reflects the fact that people in the city do not make any effort to segregate the solid waste and its proper disposal. It has been noticed that presently, Guwahati is experiencing several environmental, logistic, and health and hygienic problems which result due to the limitations and drawbacks in solid waste management in the city. Some of these problems are addressed below.

6.3.1 Problems with non-segregated plastic waste

Because of the lack of source segregation, plastic waste is available with biodegradable solid waste. The rag pickers are also not interested to collect the non-recyclable plastic (NRP) waste from the mixed waste as it has no 'waste value'. The plastic waste mixed with biodegradable solid waste blocks the microbial attack on the biodegradable materials and prevents biodegradation (Kashyap et al., 2010). As a result, the un-decomposed and semi decomposed solid waste causes land degradation.

6.3.2 Problem of haphazard dumping

At the present scenario, inhabitants of Guwahati are habituated with 'throw away and indiscriminate dumping culture' which create lots of environmental problems. Moreover, most of the citizens in Guwahati use to insert the biodegradable waste in the plastic carry bag and throw away haphazardly. Observations on the haphazard dumping of solid waste are as follows.
(i) Based upon the dustbin a vast area is scattered with the solid waste. Scavenger animals like dog and crow take active roll on scattering the SW around the dustbins. Moreover, a portion of solid waste always remains in the dustbins after lifting of the waste from the bins. Thus, an unhygienic condition with faulty odour is created around the dust bins. The bins along with the waste materials scattered around it harbour various types of microorganisms, some of which may cause diseases. Thus, haphazard dumping creates the problem of health and hygiene.

(ii) During rainy season, the accumulated plastics around the bins are washed away and help in clogging of drains. Plastics also block the degradation of biodegradable SW deposited inside the drains which is one of the prime causes of drain bed elevation in Guwahati. Thus, the unorganised disposal of plastic waste helps in clogging of drains in City favouring the creation of flash foods (Shwetmala et al., 2011) in the city.

(iii) Low lying areas are also affected due to haphazard dumping. During rainy season, rainwater washes away the solid waste and deposited in these areas which act as the reservoir of excess rain water. Due to the deposition of solid waste in these areas, it become shallow leading to the occurrence of flood. On the other hand decomposed and semi decomposed solid waste in the low lying areas are becoming the major source of various diseases along with faulty odour. Moreover, decomposed solid waste is also responsible for ground and surface water pollution through leachate. The present practice of dumping of the City’s unsegregated garbage at the low lying places is developing waste land day by day (Phukan et al., 2005).

(iv) Due to the use and throw activities of the inhabitants, most of the roads are becoming dirty. Throwing of SW along with plastic on the roads blocks the ‘link holes’ of the drain which prevent the flow of rain water from road to the drain. Decomposed and semi decomposed SW in road side are also becoming the source of various diseases along with faulty odour and dirty surroundings.

(v) Haphazard dumping of SW in market places makes it dirty and unhygienic. Decomposed and semi-decomposed SW in the market areas are becoming the
major source of various diseases along with faulty odour. Especially during rainy season, the situations of most of the markets become intolerable with faulty odour.

(vi) Scattered solid waste in and around the hospital and nursing homes in Guwahati are creating dirty and unhygienic condition. Due to the lack of proper treatment facilities, biomedical waste in most of the hospitals is becoming the major threat of various diseases.

6.3.3 Condition of Rag pickers

Studies also showed that though the rag pickers are contributing significant role on solid waste management in Guwahati, they are totally neglected and surviving with hard living in pathetic conditions. Many children begin working as rag pickers at the child age of 8 or 9 years. Most of them are never attend school and there is no any facility for informal education. The present work expose them to several types of health hazard like infection due to the contact with faecal contaminants, dead animals and hook worm, gastrointestinal infections, injuries and disease through contact with sharp materials and poisonous substances as they borrow with bare hands and some time even bare feet.

6.4 Present Scenario of Solid Waste Management

In most of the urban areas, a single choice of method is frequently unsatisfactory, inadequate, and not economical (Raykar et al., 2011; Sivanantini et al., 2011). Therefore, the whole world today is looking forward to integrate solid waste management systems for mitigation of waste related issues to obtain clean and green urban environments (Al-Salem et al., 2009). Considering the present scenario of solid waste generation, Integrated Solid Waste Management System (ISWMS) is widely accepted to minimize the health hazard and environmental degradation (Jeffry et al., 2009). ISWMS involves the selection and application of appropriate technologies, techniques, and management practices to design a program that achieves business goals and objectives, while minimizing operating costs and environmental harm (Ahmed et al., 2011). Its basic purpose is reducing the amount and toxicity of wastes at the source, recycling, reusing or composting as much of the waste as is economically reasonable.
Use of an integrated approach for managing solid waste has evolved in response to the regulations developed to implement various approaches (Tchobanoglous et al., 1993; Visvanathan et al., 2011). Integrated Solid Waste Management can also take part on employment generation in urban areas (Rosario, 2011). There are a number of examples from all over India and around the world where communities have practiced for managing their waste locally and set up successful community-based waste management models (Chanakya et al., 2009; Shilpa, 2011). Private sector also may play significant role on successful solid waste management (Barton, 1995). Burning the waste cannot be economically recycled to generate heat in waste-to energy facilities (Sharma et al., 2011). The approach is not a hierarchical scheme, but is synergistic in nature (Narayan et al., 2011).

The components most often associated with ISWMS include – Source segregation, Source reduction and reuse, Source collection, Composting and vermicomposting, Incineration and application of RDF technology for generating electricity and finally Land filling.

6.4.1 Source segregation

Source segregation is the first step of solid waste management which can lead a positive step towards sustainable solid waste management (Ghosh, 2011b; Singh et al., 2011). In this respect two types of litter bin for both biodegradable and non biodegradable should use by all the waste generators (Singh et al., 2009).

6.4.2 Source reduction and reuse

Source reductions include the prevention of flow of waste materials into the land field and enter the municipal solid waste management system. Some of the strategies include – (i) Reusing the existing products or packaging, for example plastic carry bag, pet bottle, and reconditioned batteries etc. Reusing refers to repeated use of a commodity, (ii) Elimination of excess packaging and packaging materials that is difficult to recycle and (iii) Providing strict guidelines and enactment of rules for the business house to carry back the discarded plastic items from the consumer for recycling.
6.4.3 Source collection

Source collection is an essential part of Solid Waste Management Practices. Collection of Segregated Solid Waste should be vested to the local NGOs from all the sources including household, commercial establishments and different institutions etc. (Lingaih et al., 2011).

6.4.4 Recycling

Recycling is defined as the collection materials like paper, cardboard, metal, glass and plastic etc. and manufacturing them into a new product. Increasing demand for recycled materials in the country could be achieved through several measures (Singh et al., 2011). Recycling of waste plastic into useful semi-conducting materials can also play a significant role (Deepathi, 2009).

Recycling and thereby waste reduction will play an important role in any future waste management strategy particularly in low income group of cities (Jha et al., 2011). It is not a complete process unless the legal and institutional framework can create markets for the recycled products that can beneficially utilize the materials picked up from the curb. The technical and engineering function of waste management particularly on recycling part, special care should be taken so that waste of recycling industry should not harm on water bodies (Muditha et al., 2011). The waste management / disposal field is in a constant state of flux and appropriate solutions should be innovative, as well as technically and economically feasible.

Few measures of recycling to be effective include –

- Imparting awareness to discourage the "throwaway" mentality and impose ban on disposable items. Legislation should also require that recyclable materials will be recycled and should ban disposal of these materials.

- Governmental regulations and policies that encourage the use of virgin materials through taxes, incentives etc. should be revised to discourage the use of virgin materials and promote the use of recycled ones.

- The establishment of stable markets for recycled materials is essential. Legislation should promote procurement of products containing a high content of recycled and recyclable materials and government contracts should specify products with the highest practical percentage of recycled content.
• Products and packaging materials should be conspicuously labelled to indicate recycled content, including post-consumer content, recyclability, toxicity and appropriate disposal. Uniform governmentally approved standards should be applied to terms commonly used for product labeling and promotion, such as, "biodegradable," "recycled," "recyclable," "post-consumer waste," and others.

• Economic considerations of recycling should include avoided disposal fees, the avoidance of future clean-up costs, and the costs of future land acquisition, transportation, and facility development. Disposal cost savings of recycling programs should be publicized. Disposal surcharges may be used as means of financing recycling programs.

• Land-use planning should provide for siting for recycling and other waste management facilities. Regulations should assure compatibility with surrounding land uses, minimal negative impacts on residential neighborhoods and construction to minimize litter.

• Household and small quantity commercial toxic and hazardous wastes should be segregated, labelled and collected separately in community-level programs that recycle, treat, or otherwise safely manage those wastes. Product and disposal charges should be considered as means of funding these programs.

• Convenient recycling opportunities and sufficient incentives to recycle should be provided to all residents. Collection routes, schedules and fees should be designed to promote efficient and economical collection of recyclable materials. Joint planning by labour/environmental groups to minimize contractual problems and other issues involving municipal personnel and to maximize environmental benefits is encouraged.

6.4.5 Composting

Composting involves the collection of organic wastes and treatment of this organic material in such a way that it decomposes to humus and the utilization of the co-product as a soil conditioner (Kalyani et al., 2009). Anything that is naturally degradable can be thrown into a compost bin (Singh et al., 2011). These include food and organic waste created by food processing plants, kitchens, galleys, animal feedlots,
yard work, and municipal sewage treatment plants etc. Paper, leaves and grass clippings can also be decomposed in this process and the end product can be used as manure (Narkhade et al., 2009).

It has been estimated that up to 50% of all domestic solid waste is kitchen waste, which in principal could be used for the home manufacture of compost (Wong et al., 2011). It is therefore highly desirable that the public should be encouraged, wherever possible, to set up their own compost heap at home (Sarma, 2011). The use of kitchen waste in compost heaps will certainly have a positive impact on the quanta of solid waste, which though limited could well be significant. Composting is thus an excellent method of recycling biodegradable waste from an ecological point of view (Pathirana et al., 2011). However, many large and small composting schemes have failed, because composting is regarded as a disposal process and not a production process. It is essential as in any production process to pay careful attention to the marketing and the quality of the product.

Some of the strategies in this area include –

- Composting of kitchen and yard wastes at the household and community level should be encouraged through public education and dissemination of information on composting.

- Organic materials such as kitchen waste, yard waste and wet or soiled paper that cannot be recycled should be composted to produce a useful product. If source separation is not used, appropriate materials should be separated from mixed waste for composting. Composting should serve to complement programs for recycling and reuse rather than substituting for these programs. Composting of mixed waste including recyclables and inorganic should be avoided.

- Standards should be established to set levels of inorganic materials, heavy metals, and organic chemicals in compost appropriate for the use of the compost. Strict control of the incoming waste and periodic testing should be used to insure that these levels are not exceeded.

- Wastewater pre-treatment and treatment should be sufficient to make sewage sludge safe as a soil conditioner or for composting with food and plant wastes. Application
of compost or sludge to the land should follow guidelines that will protect the environment and public health.

6.4.6 Vermicomposting

The earthworms assimilate organic waste and discharge beneficial products known as vermicompost or vermicast. Vermicomposting is one of the important measures to improve and safeguard the environment along with improvement in quality of horticultural crops. Compost prepared by the earthworm not only fulfil the gap between the supply and demand of the compost required for crop production, but at the same time eliminate the organic waste generated in the village and cities in a simple way (Jadia et al., 2009).

6.4.7 Biogas and biogas electricity

Biogas is a by-product of decomposition of organic matter in the presence of water by anaerobic bacteria (Saha et al., 2011). In the absence of oxygen, anaerobic bacteria consume the organic matter to multiply and produce biogas (Bingemer et al., 1987). Biogas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide, the major constituent being methane. Biogas is typically composed of 60% methane and 40% CO₂. It is similar to natural gas which is composed of 99% methane. Any organic waste has the ability to produce biogas like human excreta, cattle dung, fruit and vegetable waste, slaughterhouse waste, meat packing waste, dairy factory waste, brewery and distillery waste, etc. Biogas is also a non-polluting, clean and low cost fuel which is very useful for rural areas where a lot of animal waste and agricultural waste are available.

6.4.8 Incineration

Worldwide, incineration is the second choice method of waste management, after landfill (Ramchandra et al., 2007). It is the combustion of wastes in a controlled way in order to destroy it or transform it into less hazardous, less bulky or more controllable constituents. An incinerator is generally defined as any furnace used in the process of burning solid waste for the purpose of reducing the volume of the waste by removing combustible matter. Emissions of concern include particulates and potentially harmful pollutants depending on what is being burned. Incineration may be used to
dispose of a wide range of waste substances including municipal solid waste, industrial waste, commercial, clinical and certain types of hazardous / non-hazardous chemical wastes.

6.4.9 RDF technology

The municipal solid waste can be considered as a source of energy (Banerjee et al., 2009). Refuse-derived fuel (RDF) or solid recovered fuel is a fuel produced by shredding and dehydrating municipal solid waste (MSW) in a converter or steam pressure treating in an autoclave. RDF consists largely of organic components of municipal waste such as plastics and biodegradable waste. RDF processing facilities are normally located near a source of MSW and, while it may also be located at a remote location.

An appropriate proportion of the garbage is used for the RDF plant to generate power (Sengupta et al., 2009). Converting garbage to RDF would reduce volume by 5 to 10 per cent. Garbage is converted into pellets that are burnt to generate power or sale independently. Around 100 metric tonnes of garbage can produce one megawatt (MW) of power. RDF is extracted from MSW using mechanical heat treatment, mechanical biological treatment or waste autoclaves. Advanced RDF processing methods (pressurized steam treatment in an autoclave) can remove or significantly reduce harmful pollutants and heavy metals (Dogru et al., 2009).

6.4.10 Land filling

It refers to the scientific dumping of municipal solid wastes using an engineering facility that requires detailed planning and specifications, careful construction and efficient operation. It is regarded as one of the best methods of solid waste disposal, if there is sufficient land availability. It is generally safe and comparatively inexpensive. Despite apparent simplicity, there are certain problems that can only be avoided by proper landfill design, construction and operation. The common categories of municipal solid waste land filling facilities are –

- **Selected Waste Landfills:** Selected Waste Landfills are defined as disposal facilities, which accept selected types of refuse. Wastes received at these landfills may include: demolition, land clearing and construction (DLC) debris; solid industrial wastes (excluding all hazardous wastes) such as foundry sands; and,
where recycling options are not available or feasible and only with the approval of the authorities, bulky wastes such as large appliances ("white goods") and derelict motor vehicles. Generally, these Selected Waste Landfills receive only a few types of waste, which should each be discharged to discrete areas of the site.

- **Sanitary Landfills**: Sanitary Landfills are defined as disposal facilities which are normally but not necessarily, located in areas having populations of 5,000 or more and which may accept all types of municipal solid wastes. Sanitary landfills are normally required to comply with all the criteria for landfill sitting, design, operation and closure.

- **Modified sanitary landfills**: Modified Sanitary Landfills are defined as disposal facilities, which may accept all types of municipal solid wastes. These facilities are normally but not necessarily located in areas serving populations of fewer than 5,000 people where a regional or cooperative waste disposal system with neighbouring communities may not be practical or feasible.

### 6.4.11 Plastic waste and its management

Today's major problem in SWM is created by the plastic waste which is mixed with biodegradable solid waste (Bondopadhyay *et al.*, 2004). Plastics are of two types – Recyclable and Non-recyclable. Only similar grade of plastic can be moulded for recycling. Non-recyclable plastics are often multilayer pouch packs or sheets and therefore, cannot be moulded for recycling purposes. Out of the 50 different groups of plastics available in the markets, all types of plastic are recyclable except laminated and multilayered plastic.

### 6.4.12 Hospital waste management

The primary objective of hospital waste management is to eliminate or reduce the hazardous waste (Radha *et al.*, 2009). The hospital waste management involves mainly three steps – segregation of waste, waste handling and storage, and treatment and disposal of waste. The waste segregation helps in minimizing the amount of potentially hazardous waste that requires specialized treatment and disposal and as well as it controls the spread of infection within the hospital. In general, the methods and machineries used for treatment and disposal of hospital waste are – (i) Incineration, (ii)
Microwave, (iii) Autoclave, (iv) Hydro-clave, (v) Sanitary land filling, (vi) Effluent treatment plant (ETP), (vii) Needle cutter or destroyers and (viii) Open dumping.

6.4.13 Roll of rag-pickers

There is a general misconception about the rag pickers that they are the culprits behind littering the cities (Roy et al., 2009). In reality, they play an important role in segregating the garbage particularly plastic waste from biodegradable SW before it is collected for being dumped. This activity requires no skills and is a source of income for a growing number of urban poor (Sarma, 2009). Most of the rag pickers are not independent but work for middlemen or sub dealer who purchase segregated recyclables from them on pre-decided rates.

6.5 Suggested Sustainable Solid Waste Management for Guwahati

Integrated Waste Management encompasses adoption of one or more of above mentioned technologies, in tune with the local conditions. Effective waste management should be based on communities, industries, and individuals taking responsibility for their own wastes. Local governments should be empowered to develop their own solid waste management programmes. In priority order, management plans should include – waste reduction, reuse, recycling and materials recovery, in addition to adoption of innovative technologies. On these viewpoints, the following solid waste management plans are suggested for Guwahati city.

6.5.1 Suggested measures for Plastic Waste

It has been observed that at the present scenario of solid waste management in Guwahati, plastic waste is creating the major problem. Once the plastic waste is managed, then biodegradable solid waste in the land field will not create any problem rather it will act as soil conditioner.

To know about the generation of plastic waste from the households and its type (RP and NRP), a study was conducted in Guwahati City. In this process 10 wards under the Guwahati Municipal Corporation were selected for study of household generation of recyclable plastic and non-recyclable plastic (Kashyap et al., 2010a). It is estimated that out of the total plastic generated from household 60% is recyclable plastic and 40% is non-recyclable plastic (Table 6.1).
Table 6.1: Generation of recyclable and non-recyclable plastic in Guwahati

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Ward No.</th>
<th>No. of Household</th>
<th>Population</th>
<th>Total Plastic (kg)</th>
<th>Recyclable Plastic (kg)</th>
<th>Non-recyclable Plastic (kg)</th>
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<td>747.12</td>
<td>448.25</td>
<td>298.61</td>
</tr>
</tbody>
</table>

The suggested measures for the management of plastic waste are –

- Segregation of plastic waste at source.
- Source reduction – Encouraging the citizens for optimum reuse the plastic waste and to produce different useful household products.
- Door to door collection of the “segregated plastic waste” from the source on bi-weekly or monthly basis with the help of organized rag-pickers and others.
- As the pouch packs of different vegetable edible oils, milk (other than tetra pack) and all the carry bags are recyclable; therefore it is possible to replace the non recyclable (NRP) plastic products by the recyclable plastic (RP).
- Standard marking code of each plastic should strictly be mentioned for future recycling.

It has been observed that unless and until people will get some benefit, they will never accept any additional burden to segregate the solid waste at source. Therefore, it is necessary to make the source segregation programme in a professional way, where
people will participate due to their own benefit and will be able to earn money from their segregated solid waste. Under the research work, a special type of litterbin was developed for the disposal of plastic waste as someone can keep their plastic waste to earn money.

Proper management of MSW can play a significant role in national progress where, solid waste is the only available urban natural resources which can be utilized under “waste to wealth concept”. In this respect composting/Vermicomposting of biodegradable solid waste and recycling of non-biodegradable solid waste is the best suitable option for sustainable solid waste management. Once the concept of household level backyard Vermicomposting is established then entire scenario of solid waste management in Guwahati City may be changed. Where, biodegradable solid waste generated from the households could be managed at source along with the generation of resources.

6.5.2 Overall Suggested Management Plan

After investigation on existing waste management system, efforts were carried out to formulate an ideal and sustainable solid waste management plan under waste to wealth concept and the following management plans are suggested for Guwahati City.

(1) Source segregation is the first step of solid waste management and it is very hard and even not achieving success to segregate the non-biodegradable solid waste from the biodegradable solid waste after mixing. Therefore for successful solid waste management, enactment of rules for source segregation and compulsory backyard composting in the residence and apartments in view of source reduction of biodegradable solid waste is becoming most essential. Moreover, more than 60% residences in Guwahati have their space for backyard composting. Therefore construction of ‘compost pit’ should be encouraged and its benefits should also be highlighted for these residential houses in order to produce compost from their segregated biodegradable solid waste wherever feasible. Accordingly bio-degradable solid waste can be disposed directly to the compost pit for producing compost or Vermicompost without any intermediate dumping. In this process the need of road side dust bins, which are becoming a major source of pollution will not be required.
In the last 30 years back, there was a common trend among the citizens of Guwahati to utilize their daily generating biodegradable solid waste for producing compost within the campus. But day by day the trend is becoming obsolete due to the lack of space. Therefore, design and operation of appropriate biodegradable solid waste management systems at household level within the narrow space is becoming essential. At the same time there should some economical benefit for the sustainability of the household level biodegradable solid waste management activity.

Considering the above background, research work was involved to develop a simplified technology of backyard Vermicomposting for the reduction of the segregated biodegradable solid waste at source within a limited space with 3 feet diameter and 2 feet height on 1 feet high platform in an odor free hygienic environment. After successful practical implementation, the study is also developing the concept of producing household level organic manure and organic farming to generate individual interest for sustainable management activities.

Moreover it is also observed that instead of composting, Vermicomposting needs less space and maintaining an odor free environment with more nutrients value of the manure.

(2) Introduction of household level ‘plastic craft’ concept through awareness generation activities for source reduction of non recyclable plastic waste (NRP). Organization of different household level training programmes on production of different necessary household utensils like garlands, chair-back, table top, table mat etc. from the segregated plastic carry bags and NRP can take a major role on plastic waste management. In this respect innovation of fuel from all type of plastic waste including multilayered non recyclable plastic (NRP) in a simpler methodology can take a big role on plastic waste management and as well as on sustainable solid waste management.

(3) Organization of rag-pickers community and engage them for door to door collection of non-biodegradable solid waste. In this respect segregated recyclables including paper, card board, plastic including carry bags, metal,
glass and clothes etc. should be collected by the organized rag pickers from source. This practice will not only help to solve the solid waste management problems but will develop a concept of sustainable urban poor development along with the prevention of child labour activities as because of more earnings by the parents.

(4) Vigorous awareness generation activities on to avoid ‘use and throw practice’ and on to ‘use of biodegradable solid waste’ and ‘non-biodegradable solid waste’ specially NRP at household level for source reduction.

(5) Organizing mass awareness programmes among students, business people and local inhabitants, targeting source segregation into two categories viz. biodegradable, and non-biodegradable and also for source reduction, reuse and recycling of waste.

(6) Reduction of street and community dustbins and to facilitate direct source collection and transportation system of biodegradable solid waste to the ‘land fill site’ for composting.

(7) Modification of the existing unscientific infrastructural facilities of collection, transportation and disposal of the solid waste.

(8) Enforcement of law against littering and dirtying of public places.

(9) Enforcement of law against production and marketing of non recyclable plastic (NRP).

(10) Popularization of eco-friendly and degradable consumables like earthen cup and paper carry bag.

(11) Controlling unsystematic dumping of solid waste by the citizens including major industries and shops in public places and water bodies through legislation.

(12) Encouraging restaurants and hotels to supplying refused food items and other organic waste to piggery / poultry.

(13) Earmarking areas for setting up of hazardous industries away from dwelling places and city areas.
(14) Set up waste management systems, preferably composting and Vermicomposting, in educational institutions and develop the habit to use the litterbin to stop 'throw away' culture.

(15) Financial constraints should not adversely affect the speed and efficiency of waste collection and management processes.

(16) Develop a green belt of appreciable thickness around waste processing and management sites.

(17) Measures can also be taken with the help of NGOs and resident welfare associations to streamline the activity of the informal sector for the betterment of the waste management system.

(18) Privatization of waste collection, disposal and management can be considered only after strict monitoring by the local expert bodies.