CHAPTER II
REVIEW OF LITERATURE

In this chapter, literature survey is attempted. Previous studies on urban solid waste management have been reviewed. The review has been divided into five sections. Section I deals with previous research work on the scale and trend in the urban waste handling problems. Section II deals with review of literature on the factors behind the enormity of urban waste problems. Section III reviews earlier studies on the aspects of waste generation and collection practices. Section IV reviews previous studies related to the aspects of segregation and transportation of waste. Section V reviews past studies on alternative methods of waste recycling and waste disposal.

Section I: Scale and trend in the urban waste handling problems

In this section findings of research studies pertaining to scale and trend in urban waste generation and associated problems are reviewed.

1.1 AusAID\(^1\) studied the waste generation projection for the Bangalore city for the years 2005 and 2010. Lower bound, mid-range and upper bound waste projections were prepared to illustrate the uncertainty in the estimates with the assumption of the per capita waste generation growth rate of 1% and 5% respectively. The findings of the study revealed that the quantity of municipal solid waste generated in Bangalore city, based on the mid range estimates was expected to increase by approximately 10% over the five year period 2000-2005 and approximately 25% during the period 2005-2010. The waste generation was estimated to range between 3300 and 4000 tonnes per day by 2005 and from 3800 to 5300 tonnes/day by 2010. The waste projection at
lower bound, put the figures at 2051 tonnes/day for 2005 and at 2321 tonnes/day for 2010. The mid range estimate put the figure at 2134 tonnes/day for 2005 and at 2538 tonnes/day for 2010. The upper bound estimates put the projected waste at 2493 tonnes/day for 2005 and at 3600 tonnes/day for 2010.

1.2 A study conducted by TIDE\(^2\) estimated the municipal waste generation rate by source in Bangalore. It was found in 2001 that residential waste constituted 54 % (780 tonnes/day), market waste constituted 14 % (210 tonnes/day), hotel & restaurants contributed 20 % (290 tonnes/day), commercial premises generated 6 % (85 tonnes/day), slums generated 1 % (20 tonnes/day), hospitals added 2 % (25 tonnes/day) and street sweeping, parks, open spaces collectively contributed 3 % (40 tonnes/day) of municipal waste.

1.3 The composition of solid waste management options in Bangalore was studied by Reyer Gerlagh and Buekering P. Van, et.al\(^3\). The study identified in 1999 that out of the different SWM options, re-use worked out to 19 %, recycling 43 %, composting 7 % and disposal worked out to 31%. The composition of Bangalore solid waste consisted organic matter of 75 %, paper content of 1.50 %, metals 0.10 %, glass 0.20 %, textile 3.10 %, plastic 0.90 %, ash and dusts 12 % and others (including bones, stones and wooden matter) 7.20 %.

1.4 Ravi Agarwal, Rakesh Ranjan and Papiya Sarkar\(^4\) in their article on “E-Waste Crisis: Around the Corner”, attempted to examine the current situation on management of e-waste (electronic waste) in India. They explained that the
changing life style of the people and urbanisation have led to increasing rates of consumption of electronic goods. The dumping of e-waste into India from developed countries in the form of huge quantities of monitors, printers, keyboards, CPU etc., has complicated e-waste management problem in India. It was estimated in 2001 that there were 5 million PCs in India of which 1.38 million were either 486 processor or below, which would add to waste stream for disposal. The shift in the pattern of governance (e-governance) and infrastructure reforms had led the application of information technology in a big way. It was suggested that the management of e-waste should be assessed in the broad framework of Extended Producer Responsibility (EPR) and the Precautionary Principles.

1.5 Beukering, Madhushree, Reyer G, et.al. made an attempt to ascertain and quantify the solid waste generated in Bangalore city. In 1999, it was estimated that Bangalore generated about 3,613 tonnes of solid waste per day including industrial waste. The households contributed 650 tonnes (18%), commercial establishments contributed 1436 tonnes, (markets 369 tonnes, hotels 1066 tonnes) 40 %, institutes generated 128 tonnes, (hospitals 20 tonnes, offices 15 tonnes and the educational institutes contributed 92 tonnes per day) 3.5 % and the rest accounted for balance 39%. The major constituents of solid wastes were reported to be organic and biodegradable (43 %) and non-biodegradable and recyclable (36%). The study concluded that the commercial establishments are the major contributors of solid wastes in Bangalore.
Asnani attempted to identify municipal waste generation rate by source. In 1995, the findings revealed that households contributed 40% by weight (1000 tonnes per day), shops, establishments, offices and institutes generated 24% (600 tonnes/day), market contributed 24% (600 tonnes/day) and others constituted 12% (300 tonnes/day).

Kamala A, Kanath Roa. D.L reported that the solid waste could be broadly classified into seven types as follows i. Residential or household waste consisting of leaves, food waste, paper, glass etc. ii. Commercial waste due to activities of offices, markets, hotels etc. iii. Industrial waste like food processing residue, ash, plastics, packaging waste etc. iv. Building construction wastes such as bricks, sand, stones etc. v. Hospital waste composed of blood, limbs, parts of human body, emptied medicine containers, etc. vi. Bulky waste such as trees, furniture, telephone poles etc. and vii. Hazardous waste comprising of toxic material, explosives, radioactive material etc.

Jamwal N has highlighted the management of e-waste in different countries of the world. In India, it was estimated that the manufacturers and assemblers alone were creating 1050 tonnes of e-waste every year. It was reported in 2003 that there were about 12 million PC's, 13 million mobile phones and 70 million televisions, which would enter the waste stream. The Hazardous Waste Rules, 1989 do not cover e-waste in India. In Australia a permit is required for all export and import of e-waste. Switzerland introduced an ordinance on the return, take-back and disposal of electrical and electronic appliances. The
European Union introduced restriction of the use of certain hazardous substance in electronic goods. It was estimated that in Europe the volume of the e-waste was increasing by 3-5 percent per annum, three times faster than that of municipal solid waste. It was suggested to have strict international regulations on transboundary movement of hazardous waste and their disposal and urged to make electronic product ecofriendly.

1.9 The report of United Nations (UN) 1999, on “Environmental sound management of solid waste and sewage related issues” projected a five-fold increase in global waste generation by 2025. In the developing countries, the prediction estimated that waste production would double during the next decade, 2001-2010. In the developed world, per capita generation of waste has increased threefold over the past 20 years. The report explained that in developing countries, attempts to promote waste minimization have been hampered by lack of data on waste production at source and waste collection and disposal. It was reported that there is a direct epidemiological relationship between inadequate waste management and the increase of diarrhea, respiratory and skin diseases. The report suggested paying special attention on peri-urban areas to support urban development, where most of the waste is disposed. The report concluded that waste minimization policies and strategies for decision making need to be developed, based on current and projected rates of waste generation by different sectors.

1.10 AusAID studied the future treatment capacities / disposal requirements of solid waste and population projection for Bangalore city. The projections on
the quantities of the waste to be accepted for biological processing, recovery for recycling and landfill disposal of final rejects have been prepared for 2005 and 2010 through three estimates, lower bound, mid range and upper bound. The biological processing/compost (organic waste) estimated to range between 1450 and 1725 tonnes in 2005 and between 1600 and 2400 tonnes in 2010. Waste to be landfilled was estimated to 600-700 tonnes/day by 2005 and 650–900 tonnes/ day by 2010. The waste recovered by recycling is estimated between 1000 and 1200 tonnes/ day over the decade.

1.1 Sundervadivel and Vigneswaran\textsuperscript{11} in their paper on “Sustainable Municipal Solid Waste Management in developing countries -The experience of smaller towns in India”, investigated the trend in solid waste generation and composition in small and medium towns (SMT) and metropolitan cities in India. The sample towns selected for SMT were from Tamilnadu state viz. Andipatti, Bodinayakanour, Cumbum and Theni. The percapita waste generation was 203 g/day and compostable fraction was 69 \% for SMTs . For metropolitan cities per capita waste was 456 g/day and compostable fraction was 41.8 \% of the total. The soil fraction was 21.4 \% and 40.3 \%, paper content was 3.4 \% and 5.7 \% and plastic content was 3.5 \% and 3.9 \% respectively for SMTs and Metro cities. It was suggested for SMTs to adopt semi-mechanized aerobic windrow composting technology to convert waste into good quality compost at lower cost.

1.12 Henry Pepper\textsuperscript{12} in his paper on “Prevention of Littering–Measuring Environmentally Desirable Behaviour”, found that men litter more than
women and women use bins more than men. He found that old people litter more when alone, and for every other age group, people litter less when alone. Students litter more than other people do.

1.13 Bhat Sairam in his article on ‘Legal Response to Manage the Challenges of Waste in India’, has explained that the waste is categorized by regulatory instruments at the national and international level according to two characteristics: (i) their source whether municipal or industrial, (including agricultural and mining) and (ii) their hazardous qualities (non-hazardous, hazardous and ultra hazardous qualities). It was reported that institutional and commercial waste consists mainly of paper, plastic, rubber, discarded furniture etc. Domestic waste consists of garbage, plastics, cloth, rubber and wood packing material.

1.14 Meenakshi.V. and Muthuchelian.K have attempted to study the impact of municipal solid waste on environment and health in the study area of Gundaru river basin in Tamilnadu, where municipal solid waste are directly discharged into the river. The study involved collecting various samples i.e. water sample for analysing water quality and microbial diversity of Gundaru river contaminated by dumping of solid waste in river water, and the blood samples from Gundaru river bed dwellers (Thirumangalam area) for hematological parameters and common illness for disease occurrence in Thirumangalam Gundaru river basin. The study concluded poor health status of the dwellers of the referred basin was due to consumption of river water. Common diseases noticed mostly were water borne. The study suggested four categories of
waste minimization techniques viz. improved operation, modification of equipment, production process changes and recycling and reuse.

1.15 David Wilson, Andrew Whiteman and Adam Read\(^{15}\) presented a new methodology in their paper on “Strategic planning for solid waste management -- An interactive kit for developing countries”. They proposed seven steps strategic planning methodology, which focussed on understanding the baseline situation of city and the likely future requirements for municipal solid waste management (MSWM) in the city or region. It emphasized the need for an integrated approach, including institutional development, financial sustainability and public awareness and participation, alongside the technical aspects of waste collection and recycling and waste treatment and disposal.

1.16 Somashekar.R. K and Kiran Rajashekariah\(^{16}\) in their paper on “Solid Waste Management in Bangalore: Left Much to be desired?”, classified solid waste into eight major classes based upon the sources of waste generation. These are residential, industrial, commercial, institutional, construction, demolition, municipal services and agricultural.

Section II: The factors behind the enormity of urban waste problems

In this section research studies on the factors responsible for the enormity of the problems of urban waste management are reviewed.

2.1 Bhargava S.\(^{17}\) in his article “Taming the Indian Public for Solid Waste Management”, attempted to identify the factors and reasons behind the enormity and pathetic situation of solid waste management in India. It was
identified that the inefficient municipal administration, management of solid waste issues not by experts, shortage of finance, ignorance of municipal corporators, indiscriminate use of polythene, gross unawareness about the implications poor SWM and unconcerned and undisciplined public as factors behind the enormity. The solution strategies for the problem suggested by him included: To periodically organize seminars and workshops by the municipal corporators and NGO's for the sole purpose of education and create awareness, to introduce general curriculum in schools and colleges on waste management or environmental sanitation issues, to educate children at home by parents on general sanitation, to give priority for waste issues by the media, to ban plastics and to encourage environmental friendly material.

2.2 The relationship between income levels and waste generation at the household level in Bangalore city was investigated in 1999 by Beukering, Madhushree, Reyer .G. et.al\(^{18}\). The finding revealed a low positive co-relation \(R^2 = 0.09773\) between income level and waste generation.

2.3 Reyer Gerlagh, Beukering .P.V, Verma.M\(^{19}\) made an attempt to identify factors influencing the quantities and composition of solid waste. The study found that the average level of income, growth of population, social behavior, climate, industrial production and existence of market for waste material contribute for solid waste. The distinction between waste management practices of developed northern countries and developing southern countries was also studied. The most recyclable goods in northern countries are supplied by households on a voluntary basis. The main sources of these materials in the
southern countries are the waste pickers and itinerant waste buyers who collect these materials for their livelihood. In developing countries, collection and proper disposal of waste are the main problems. Despite the high cost involved, the collection of disposal waste is highly organized in developed countries and their priority is finding ways of increasing recycling and improving safety of incineration. The study concluded that the constraints and inefficiencies experienced in SWM are mainly due to an undue emphasis on technology, while ignoring SWM’s social, ecological and economic characteristics.

2.4 Report of the Committee constituted by the Supreme Court of India to study the aspects of solid waste management in class I cities has cited the reasons for deficiencies in MSW management services as institutional weakness, under productivity of SWM staff & equipment, legal aspects, financial difficulties and lack of community involvement. In the context of institutional weakness, the role of SWM department was not well defined. The duties were not well discharged due to lack of accountability. Under productivity of SWM staff & equipment is largely due to lack of supervision, motivation and large-scale absenteeism. Equipments given to sweepers are outdated and inefficient. Transport vehicles productivity was very poor because of high downtime, inadequate loading, inefficient deployment and wasteful trips. In most urban areas, the services were not extended to urban slum encroachments. In the financial context, the cost recovery has not been attempted seriously in SWM services. Besides community apathy for improved SWM services and cost sharing contribute to the problem.
2.5 Ravi Agarwal and Sanjay K. Gupta investigated the relationship between changing urban landscape and solid waste management. Massive migration of population from rural to urban centers has led to new consumption patterns and social linkages with unsought problems on SWM. As a result of urbanisation, Indian waste is expected to grow substantially in its organic content and only marginally in non-biodegradable elements except paper. In 2002, it was estimated that organic waste would go up from 40% to 60%, plastics from 4% to 6%, metal from 1% to 4%, glass from 2% to 3%, while paper will increase substantially from 5% to 15%. Others consisting mainly of ash, sand and grit will decrease from 47% to 12% indicating a shift from coal to gas and other cooking fuels.

2.6 Somasheker R.K. and Rajashekariah correlated the GDP growth, population growth and solid waste generation. It was reported that solid waste generation is a consequence of material consumption by the community and the increase in waste quantities is assumed to be comparable to annual increase in GDP. Both consumption of material and generation of waste by community are directly related to GDP. It was reported in 2002 that Bangalore GDP is growing at about 6.7% per year. By assumption of increase in per capita generation of waste by 6.7% every year, the annual rate of increase in solid waste generation was estimated to reach 0.38 kg/capita/day. Based on growing population and current economic growth rate, it was calculated and projected that the Bangalore City would generate about 3500 tonnes of waste per day by 2005.
Klundert A. Van de & Anschutz J. attempted to analyze the common problems encountered by municipalities, which cause failure in the system and consequently lead to enormity of urban waste problem. It was found that the system failure includes lack of a comprehensive policy framework for waste management and shortage of tools to analyze and improve efficiency and effectiveness. Inadequacy of equipment at the disposal of municipalities, their poor maintenance, little spare parts and their gross inappropriateness for the local conditions are factors behind the sorry state of affairs. All these factors were exacerbated by the increase in population and volume of waste per household. It was mentioned that the under-functioning of staff was due to lack of motivation, feeling of low status and low salary. Difficult working conditions compounded the problem. Financial problems because of rising costs and inadequate revenues are most pressing. Inefficient waste processing facilities and increasing cost of transportation and disposal due to regionalisation of disposal, the long haul distance to disposal site etc. stand behind the financial problems. Behavioral factors included illegal dumping of waste, misuse or non-use of containers, damaging or stealing container bins and resistance to levy of service charges and non-co-operative citizens. The study proposed to have Integrated Sustainable Waste Management (ISWM) to provide solutions, which are based not on money or equipment, but on changing social, institutional, legal, and political conditions. The study suggested three dimensions of ISWM as: i. the stakeholder involvement, ii. elements of waste system iii. aspects of local context in planning waste management system.
2.8 Satish kumar.R, Chanakya.H.C.N., Ramachandra T.V\(^24\) in their report on “Feasible Solid Waste Management”, examined the causes of mismanagement and key constraints in management of solid waste. The study reported that the people from rural areas were migrating at an alarming rate for employment and better quality of life. Absence of proper municipal amenities made municipal authorities forced to take adhoc measures, which compounded the problem of solid waste further. Burgeoning population, industrialization, uncontrolled economic growth, unplanned economic activities and lack of integrated and holistic SWM approach were other factors. The study suggested that the success of waste disposal practices depend on overcoming the constraint of the municipal capacity to deal with the SWM, political commitment, financial cost recovery, appropriate technical guidelines relevant to developing countries, institutional responsibilities and adequate legal provisions.

2.9 Harjet Singh and Usha Subramaniam\(^25\) highlighted the ill effects of lifestyles and social wasteful habits on generation of waste in their article, “Environmental Education for Sustainable Development- An Indian Perspective”. They explained that the social habits of disposal of waste not only result in water and air pollution but also make our cities and villages unclean and unhygienic. The wasteful habits and lifestyle contribute quite significantly to the rapid erosion of precious natural resources. It was stressed that Government action cannot succeed unless the values which people cherish are in accordance with the need for protection of environment. It was suggested that sustainable lifestyle by individual is must for sustainable
development. Reversing unsustainable lifestyles, attitudes and values of people were reported as inherently complex and cannot be achieved without the whole-hearted support of the public. It was concluded that environmental education and creation of awareness have a great importance in change of social behavior and sustainable lifestyle.

2.10 Abdul Ghafoor Ghaznawi has strongly stressed that humanity's lifestyle and priorities are determining factors in shaping the pattern of development. He emphasized that for balanced and sound development, man's lifestyle and priorities have to be defined and refined with respect to needs concerning energy, food, water, shelter, etc. It was emphasized that it was necessary to curb wastage in the daily life of individual and in the technological processes and their output as well. It was reported that new lifestyle and priorities were the precursors of new technologies. It was suggested that developmental objectives, processes and outcomes ought to be dovetailed with the human needs and their readiness for handling and sustaining development in the context of regenerating potentialities of the environment and its resource at the local, national regional and global levels.

2.11 The World Resource Institute estimated in 1997 that 60 percent of humankind will live in urban areas by 2020. As a result of urbanization, it has forecasted that three issues to emerge as critical and suggested priorities for action. Solid waste management is one among the three.
2.12 Jagannath.V, Suresh .N, et.al. observed the reasons for exponential growth of urban solid waste as lowered social, resource and techno - management initiatives and community participation. They have also observed the solid waste is only one of the 10-12 responsibilities of the municipal local authorities. The budgetary restrictions, poorly motivated staff and sweepers, inadequate fleet of vehicles were found as responsible for solid waste problems.

2.13 The report of World Health Organisation (WHO) has revealed the facts and figures of ill effects of inadequate sanitation and poor hygiene. A well-designed sanitation intervention has proven in achieving 77 % reduction of the disease. The study has concluded that people living in areas without adequate sanitation who had no hygiene education spend six times more on medical treatments than those with sanitation facilities.

2.14 The report of World Resource Institute on the determinants of urban environmental problems reported that the determinants vary from city to city and region to region and are influenced by the variables like city’s size, rate of growth, income, local geography, climate and institutional capabilities. The findings revealed that as the wealth of the city grows, environmental degradation first increases and then eventually diminishes. As income increases, urban households consume more resource and generate more waste. However, rich devote part of their wealth to protect themselves and the problem get shift to elsewhere.
2.15 Manjunath. K\textsuperscript{31} in his article on “Garbage Dump, its Relation to Air Spora and Ground Water Contamination” has projected that by 2015 half of the world developing country population would be in cities. The Bangalore population would be 7 million by the end of 2011 occupying 565 sq.km. The urbanisation and growth of city scale cause increase in solid waste. The study found that the yield and composition of the solid waste strongly depend on factors such as population, standard of living, habit, custom, fuel consumption, industrial level, food composition, stage of social development as well as climate.

2.16 Robin Murray\textsuperscript{32} has observed that the three basic drivers of change are turning waste and waste management into a dynamic, fast changing, international economic sector. He explained that the transformation presents new choices and opportunities and provides lesson and pointers for industrial, social and environmental policy in the new post-industrial landscape. The three drivers of change were: i. concern about the hazards of the waste disposal (especially global warming) and resource depletion, ii. economic opportunities created by new waste regulations and iii. technological innovation.

2.17 Srinivas Chary. V. & Sridevi. U.\textsuperscript{33} made an attempt to study citizens’ perceptions on performance of civic service providers, deficiencies in services and the willingness of the users to pay for services in their article, “The Report Card of Hyderabad City”. The main objective of the study was to focus on public opinion on sanitation (solid waste disposal), water supply, drainage and public transport in the city. The study found in 2001 that only 61% of
households used service of solid waste disposal. 69 % of households (both in slum and non-slum) were dissatisfied with the services provided for solid waste disposal. Dumping garbage at public places, away from garbage bins was a much more serious problem in non-slum areas (60 %) than in slum areas (33 %). For municipal services, 72 % of non-slum households and 33 % of slum households were willing to pay for improved services.

Section III: Aspects of waste generation and collection practices

In this section findings of research studies on aspects of waste generation and collection practices are reviewed.

3.1 Exonora International has conducted a community survey on waste management in Bangalore. The survey included 1000 households selected randomly (100 households / ward, 10 wards). The survey concluded that: i. a door-to-door collection scheme was preferred by all respondents, ii. 76 % of the surveyed people deposit their waste into the communal waste storage units while 20 % indicated that they throw the waste onto the streets and drains, iii. 95 % of the respondents were prepared to meet the additional cost of introducing door-to-door collection scheme. 90 % of the respondents were prepared to spend amount ranged from Rs 1 to Rs 20 for solid waste services. 92 % of the respondents were aware that uncleared garbage could lead to health hazards. The survey was limited to only BMP area.

3.2 A comparative study on existing urban solid waste collection system and alternative collection option was done by Jagannath and Suresh. N et.al. It was reported that in the existing collection system, the households waste are
tipped haphazardly in and around the roadside dustbins. Apart from the anaesthetic consideration of such a system, the major disadvantage was found as the inadvertent mixing of various fractions of solid waste, which left little scope for effective recovery of recyclable and removal and transport of problematic wastes. The waste pickers were vulnerable to hazards of injury and infection from broken glass and unsanitary components. The two alternative collection options were house to house collection and collection from dustbin. Door to door collection of sorted or unsorted garbage could remove the need for maintaining roadside bin. Waste pickers littering themselves during picking the bin could be avoided. It concluded that door-to-door collection would require institutional and infrastructure support by both formal support and local NGOs. The study recommended that wherever door-to-door collection cannot be organised an alternative system of collecting segregated waste in separate, colour coded roadside bins be followed.

3.3 John Post in his article entitled, “Privatised Waste Collection in Developing Countries-Strength and Weakness” highlighted the success and problems associated with privatising waste collection in developing countries. Three case studies from Hyderabad, Accra and Nairobi were made. The study revealed that the private operators in all the three cities have proved to provide good quality solid waste collection services at comparatively low cost, leading to high level of consumer satisfaction. Privatisation has not done much to improve solid waste collection performances in deprived residential areas.
Privatisation has produced higher levels of employment within the sector, largely by extension of services. At the same time, labour conditions in the private sector were found to be consistently inferior to those in Government services (lower wages, lower job security, fewer non-wage benefits and facilities). The community participation was neglected in the design of privatisation, which had led to affect in introducing cost recovery attempts. The study concluded that privatisation of solid waste collection was certainly a promising avenue for local governments but has to be tailored to specific local conditions. The guiding hand of the state is indispensable to provide adequate provision and precautions and to insure that all relevant social and environmental concerns are considered.

3.4 Per Nilsson in his article entitled “Weighing it up: Assessing Danish Weight Based fee scheme for Collection of Household Waste” has examined the waste collection scheme on principle of ‘Pay – as – you - throw’ (PAYT) followed in Denmark. A survey conducted in 2002 revealed that 19 out of 275 Danish municipalities have introduced pay- by -weight scheme. It was found that 85,000 (4% of population) sample households participated in pay- by-weight scheme. The fee schemes were typically a combination of a basic fee per household DDK (Denmark Currency) 550 – 1200, which includes 130-350 kg of mixed waste and all the additional free services. For the waste exceeding the basic amount, 1.5 –5.0 DDK per kilogram was levied. The findings of the study did not show any difference in consumer habits between households of weight based and non weight based collection schemes, therefore it was assumed that the same amount of refuse is produced by both types of
households. It was found that on an average, 359 kg more refuse was collected per household per year in the reference municipalities than in the municipalities with weight-based collection system. 59% of the household under weight based collection scheme stated that all fruit and vegetable remains generated were converted into home compost, whereas the corresponding figure for reference municipalities was 21%. The study concluded that the weight based system is the fairest way of calculating the refuse collection fee and there should not be a flat fee for refuse collection.

3.5 Indian Market Research Bureau (IMRB 2001) conducted a baseline socio-economic survey relating to solid waste management with the purpose of: i. to generate critical socio-economic access and arrangements for sanitation related information to assist in the development of Master plan and ii. to identify poor and vulnerable groups to target project interventions. The survey covered the entire Bangalore Metropolitan area including the conurbation and green belt areas. A total of 3,937 sample households were surveyed in 2001, of which approximately 74% were in the BMP area, nearly 8% were in the conurbation area and nearly 18% were in the green belt area. The survey elicited information on various issues related to solid waste management like place of waste disposal by household, frequency of disposal, time of disposal, amount spend by household on waste disposal and level of satisfaction with present solid waste management system. The survey findings concluded that in the case of place of waste disposal by household, the vast majority of the households in BMP area have access to formal waste collection system. No households in the conurbation and green belt areas were provided with door-
to-door collection services. In case of frequency of waste disposal by households in BMP area was distributed as 88% daily, 10% in 2-3 days and 1% in 4-5 days and for the conurbation area 91% daily and 9% once in 2-3 days. In case of time of disposal, the majority of the households dispose their waste in the morning. For the amount spend by the households on waste disposal, households in the BMP area spent on average approximately Rs 14 per month on waste collection and disposal.

3.6 The study conducted by World Bank in 1999 showed that the countries with a GNP per capita less than US $ 400 produce waste less than 0.5 kg per-capita per day, middle-income countries produce 0.5 to 1.1 kg per-capita per day and higher income countries produce 1.1 to 5.5 kg per-capita per day. It was reported that in 1999 urban areas in Asia alone generated about 760,000 tonnes of waste per day and spent about US $ 25 billion on solid waste management per year. It was projected to increase to 1.8 million tonnes per day by 2025 and the calculated the expenditure at US $ 50 billion per year.

3.7 Henry Pepper made an attempt in Australia to identify the most littered item. He found that cigarettes are the most littered item generated constituting 58% of all Australian litter in 2003. The most common reasons for littering were 'too lazy' (24%), no ashtray (23%) and no bin (21%). He summarised littering behaviour was a complex issue and the use of anti-littering and litter prevention strategies should be based on an understanding of characteristics of people using local areas including their typical activities and disposal behaviour.
3.8 Somashekar . R.K and Rajashekeriah . K\(^{41}\) in their article on "Solid Waste Management in Bangalore: Left much to be desired, presented the issues, inadequacies and suggestions on solid waste management in Bangalore. The study recommended to generate database of waste at sectoral levels by BMP in order to formulate waste policies.

3.9 Ravi Aggarwal and Sanjay K. Gupta\(^{42}\) examined the relationship between composition of Indian waste and low and high-income group. The households with income upto Rs 2000 per month were categorised under low income and households with income above Rs 8000 per month were considered under high-income group. It was found in 2002 that organic matter (wet) waste was 72 \% and 82 \% in low and high-income group respectively. The plastics were found to be 5 \% and 8 \%, paper content was 5 \% and 8 \%, glass was 4 \% and 1 \% and grit was found to be 14 \% and 1 \% respectively.

3.10 Manjunath .K\(^{43}\) tested whether there was any relationship between garbage generation in an area and bacterial and fungal spores concentration in Bangalore city. There was a strong correlation (r = 0.971) between garbage production in an area and fungal spores found in atmosphere and underground water. The Bangalore soil is loamy and percolation of pollutants from garbage contaminate the ground water. The meteorological parameters like high rainfall, humidity, moderate temperature in Bangalore city were found to help the decay and compost of organic garbage very fast and released lot of fungal spores, obnoxious gases, bacterial spores and endotoxins to the environment. The air borne fungi Cladosporium spore count in 2002 was found to be around
3,066 no. / m³ in slum garbage. Hence the study concluded the possibility of severe respiratory infections, allergic pneumonites, bronchitis, eczema, contact dermatitis and headache in the population.

3.11 Sambandan V.S in his article “The Plastic Ban: Powerful interest at play” reported in 2002 that the composition of plastics in India in municipal waste was in the range of four percent and it is likely to grow up to six percent in the years ahead.

3.12 Mini Shrinivasan in her article “Conservation through waste” presented that generation of garbage was related to the socio-economic class.

3.13 Homayra Parveen Shukla in his article “Say no to Plastic” made an investigation in success of ban on use of plastic in Dhaka city. It was found in 2003 that nearly 10 million polythene bags were used and nine million were dumped everyday in Dhaka City alone. Only 10-15 percent was collected in dustbins, the rest was dumped in drain, sewage channels and open spaces. 80 percent of drains in Dhaka were found to be blocked because of polythene bags. The riverbed of the Buriganga was littered with dumped polybags to a height of 5-6 feet. The paper highlighted the role played by local media in implementing the ban successfully. Apart, the quick supply of jute, paper, cloth and other environment friendly bags was highly helpful in replacing the polythene and improving the situation.
3.14 Central Pollution Control Board (CPCB) estimated the solid waste generation in Bangalore City as 1896 MT/day in 2001. The land requirement for disposal of waste was calculated for next 10 years as 295.62 hectares. It has reported that BMP has identified 4 landfill sites at Kannanhalli, Medhigrahara, Gidenhalli and Seegehalhi for land filling.

3.15 Ammu Joseph studied the prevailing conditions of solid waste informal system in Bangalore in 1994. It was reported that 0.4 to 0.5 kg per capita of solid waste was generated in Bangalore city. Informal system accounted for, 40 to 50% of total waste collected. People involved in informal system were poorly compensated for their contribution to urban life, they were socially shunned and forced to live on the margins of society. The potential of employment generation by recycling sector could be as high as 3% of urban work force.

3.16 A study conducted by National Environmental Engineering Research Institute (NEERI) showed that in 1996 the waste generation rates were low in smaller towns and high in cities over 20 lakhs population. The range was between 200 gms per capita per day and 500 gms per capita per day. It was estimated that the average per capita waste generation (gms/capita/day) was 210 for population range 1 to 5 lakhs, 250 for population range of 5 to 10 lakhs, 270 for 10 to 20 lakhs, 350 for 20 to 50 lakhs and 500 gm/capita/day for 50 lakhs and above population sized cities.
3.17 Malini Shanker\textsuperscript{50} in her article, “Sitting Pretty on Waste!” reported in 2002 that Bangalore generates around 2,200 tonnes of waste per day. Organic waste amounts about 60 to 70 percent of total waste generated. Around 206 tonnes of plastic was generated as waste everyday and only 171 tonnes were collected as separate plastic waste by municipal authorities, thus leaving 35 tonnes of litter everyday uncollected. The study revealed that ragpickers do not collect thin plastic of lesser than 20 microns and the municipal authorities were not capable of collecting them as households do not separate the waste efficiently. The study suggested certain priorities for effective waste management as follows: i. Separation of waste and to collect separated waste efficiently. ii. The municipal authorities to collect organic waste in the morning, recyclable and plastics in afternoons and hazardous wastes in the evening everyday. iii. To allot shift work for municipal staff to accomplish the task. iv. To create an Agenda Transfer Bureau to oversee the transaction into a plastic free society and v. To standardise the packaging wares.

3.18 In his article on “Plastic Management Programme takes shape in Bangalore City” Arvind Gowda\textsuperscript{51} explained that Bangalore city generates 140 –150 tonnes of plastics per day. Accumulation of plastic in public places has increased because old paper mart agents who used to purchase plastic from ragpickers had been stopped due to stringent Central regulations against plastic waste disposal. It was reported that plastics could be recycled for 20 times. The threat to environment from plastic was more from laminated plastic pouches and multi layered plastics, which are used for packaging areca nut,
ghutka and shampoo than carry bags or containers. It was suggested that plastic management should be made as an organised sector.

3.19 A study by World Economic Institute\(^2\) examined that for low-income cities, the main solid waste problem was to extend collection services to the poor. It was reported that 50 percent of the population were without solid waste collection service. The collection services of waste management accounted for 30 to 50 % of operational budget, yet only 50 to 80 % of total solid waste generated were collected. For middle and high-income cities, collection often reaches to 95 to 100 percent of population, but disposing of waste was a key challenge. It was found that solid waste collection services by the private sector are 20 to 48 % less costly than public services. The private sector was interested to offer the waste collection service only in high-income areas of the city only where the service charges and the value of recycled materials were high. It was suggested that an ideal arrangement for collection of solid waste was a mix of public and private services.

**Section IV : Aspects of segregation and transportation of waste**

In this section findings of research studies on aspects of segregation and transportation of waste are reviewed.

4.1 ASTRA\(^3\) has analyzed the segregated waste composition of Bangalore waste in waste bins before and after waste picking done by rag pickers. It was reported that the composition of segregated waste in waste bins before and after waste picking as 8 % and 4 % for paper, 6 % and 2 % for plastics, 6 % and 1 % for glass, 3 % and nil for metals, 65 % and 78 % for vegetable matter,
and for miscellaneous items 12 % & 15 %. It has concluded that waste picking activities focus on paper, glass, metal and plastic present in municipal solid waste. These activities increase the proportion of organic matter in waste collected by sanitation workers from that deposited into community waste bins by resident etc.

4.2 Deepa. A and Hemalatha. D.S et.al\textsuperscript{54}. highlighted the difference in the composition of segregated waste during working days, non-working days (holidays) and festival days in Mysore city. The finding suggested that there was a considerable difference in the composition of segregated waste. The average moisture content during working, non-working and festival days was 27.40, 41.10 and 26.80 respectively. Moisture content has significant effect on the cost of collection, segregation and transport since moisture increases the weight of the solid waste. The percentage of composting material in 2002 was found as 66%, 75% and 78% respectively. The plastic and paper contents in solid waste were varying. During working days the respective proportions were 8 % & 5 %, during non-working days 8.75 % & 3.5 % and during festival days 7 % & 2.5 %.

4.3 Satish .R and Sunil Kumar.M\textsuperscript{56} made an attempt to study the aspects and crisis in waste segregation. They reported that waste segregation was done only by a few well-informed and motivated citizens. It was reported that with the given performance of our municipal authorities motivating communities to segregate waste was almost near impossible. More than a half of the plastics produced in India was used for packaging and these packaging materials in the
absence of segregation become source for resource loss that could have otherwise recovered or recycled. In 2002, it was reported that the plastic waste comprises 1-4 percent of total 80,000 tonnes of municipal solid waste produced everyday in the country in the terms of weight. This sums upto 800-3,200 tonnes of plastics per day.

4.4 Rajashree V. Bhothale, Vinod M. Bothale, et al. in their paper on “Solid Waste Collection, Transport and Disposal Site Selection through GIS”, highlighted the role of Geographical Information System (GIS) in solid waste transport and disposal site selection. The GIS based package PARIKRAMA (Package for Optimum Routing, Interactive Resource Allocation and Facility Management) has been envisaged for collection and transportation of solid waste. Collection and transportation system were aimed in reducing the number of vehicles operating in the area along with minimizing the time/cost of operation. The study concluded that the use of latest technology would help the planners in effective utilization of available infrastructure. The available network analysis package “PARIKRAMA” could be further customized to suit local needs.

4.5 Enzo Favovio, Attilio Tornavacca conducted a survey on the cost of different collection system of solid waste in Italy to study and compare different collection systems. The system were classified in three groups as: i. Mixed MSW, where food waste is not stored and source separation through road containers only for dry recyclable: ii. Source separation including that of food waste, based on road containers both for food waste and dry recyclable
and other residual waste and iii. Intensive source separation including food waste, dry waste and residual waste. The study concluded that on average no statistical relationship could be found on their cost per inhabitant. The study also showed that source segregation of food waste with doorstep collection could be operated with no substantial increase in the overall cost. For waste collection and transportation, the more flexible and varied the fleet of collection vehicles, the better it was since the food waste on its own needs neither mechanical loading nor compaction.

4.6 A study conducted by Central Pollution Control Board (CPCB) revealed some of the practices followed and constraints faced in collection and transportation of solid waste in Indian cities. It was estimated in 1997 that solid waste generated in small, medium and large cities and towns was about 0.1 kg, 0.3-0.4 kg and 0.5 kg per capita per day. The findings of survey indicated that in some cities, no norms/guidelines were followed in setting up waste collection centers. Each city has its own system for setting up waste collection centers, which are still using primitive methods. It was estimated that approximately 60% of waste are collected for transportation to the disposal site and the main constraints were found to be: i. non-availability of sufficient transportation fleet, ii. frequent breakdown of vehicles and iii. absenteeism of crew. The study suggested that vehicles carrying garbage to be covered. Transportation of waste to be done on everyday basis throughout the year. Vehicles and equipment to transport the waste to be synchronized with primary and secondary collection centers.
4.7 AUSAID\textsuperscript{59} has examined modes of waste transportation in Bangalore City. Three modes of transfers were identified in the waste handling process. They are: i. waste collected from generators is transferred to a local transfer station and ii. Waste from the local transfer station hauled to a regional transfer station. iii. Waste from the regional transfer station hauled to a disposal facility. It was reported that in the first case handcarts, tricycle, autotippers, mini truck are used. In the second case, autotippers, mini truck, dumper placer, ordinary truck and compactor truck are used. In the third case dumper placer, ordinary truck, compactor truck and high capacity truck are used.

4.8 Alone B.Z and Bhide A.D\textsuperscript{60} in their article on “Standards for Compost from Municipal Solid Waste”, highlighted that the improper segregation affect the compost quality. They estimated that the total quantity of municipal solid waste from Indian urban centers as 40 million tonnes per year in the 2001. It was reported that the small scale industries located within the municipal limits often dispose off their solid waste along with the municipal solid waste. In such cases, the compost will have heavy metal contents, which will be injurious to plants and in extreme cases; it may be injurious to human beings when they consume such plants. The municipal solid waste, which was found to be often deposited adjacent to the sewage drains, gets mixed with drain water subsequently transferring the parasites and pathogens to waste and thus finally carry to compost. The study suggested that the regulatory authorities should lay down the parameters for which the compost should be evaluated, based on the end use of the compost for agriculture, horticulture,
land reclamation etc. These parameters should be disclosed while selling the product with maximum permissible levels and desirable levels.

4.9 Mini Shrinivasan \textsuperscript{61} in her article “Conservation Through Waste”, presented a case study from Pune City about waste segregated by waste pickers. Scrap waste could be sorted up to 13 categories. 92% of waste pickers involved were women, whose average earning was about Rs 60 per day. The more the number of times scrap was sorted out, the more the value addition was noticed. It was found that the waste pickers salvage about 150 tonnes of recyclable scrap prior to its transportation, thereby saving the municipalities the sum of Rs 15,822,750 (Rs 1.6 crores) per annum. By implication each waste picker contribute Rs 246 worth of unpaid labour per month to the municipality. The annual contribution of scrap trade to the total income generated was reported as Pune is Rs. 18.5 crores.

4.10 AUSAID\textsuperscript{62} attempted to forecast and project the number of vehicles required for transportation of waste from generation point to disposal sites for the year 2005 and 2010 for Bangalore city. In 2005, vehicle requirements were estimated at approximately 500 primary collection vehicles comprising autotippers and/or mini trucks, approximately 670 ships of 4.5 m\textsuperscript{3} capacity, approximately 170 intermediate transfer vehicles comprising dumper placers, trucks and compactors and approximately 80 long-haul vehicle comprising bulk refuse carriers and compactors. In 2010 vehicle requirements were estimated at approximately 600 primary collection vehicles comprising autotippers and mini trucks, 780 ships of 4.5 m\textsuperscript{3} capacity, approximately 200
intermediate transfer vehicles comprising dumper placers, trucks and compactors, and approximately 100 long haul vehicles comprising high volume trucks and compactors. It has been estimated that approximately 18 local transfer stations and four regional transfer stations were required.

4.11 A study conducted by TIDE\textsuperscript{63} attempted to study segregated waste composition of Bangalore city. In residential segregated waste, the composition of solid waste in 2001 was found as 8.4 % of paper waste, 6.9 % of plastic, 2.3 % of glass, 8.1 % of dust ash, 1.3 % of clothes, 1.2 % of hazardous waste and remaining 71.5 % of organic (putrescible) waste which includes food waste, wood waste and garden trimming. Similarly the composition of commercial waste was found as 54.6 % paper waste, 16.6 % plastic waste, 0.7 % glass waste, 0.4 % metal waste, 8.2 % dust ash, 4 % clothes and 15.6 % putrescible waste. It was reported that segregated composition of total waste from all sources (includes residential, commercial, hotels, markets, slums and street sweeping) as 11.6 % of paper, 6.2 % plastic, 1.4 % glass, 0.2 % metals, 6.5 % dust and ash, 1 % clothes 0.9 % hazardous waste and remaining 72 % putrescible waste.

4.12 ISEC\textsuperscript{64} conducted a study on segregated waste composition of municipal waste in Bangalore in 1998 and found 2.9 % of glass, 6.7 % of plastic, 16.5 % of paper, 1.5 % of metal, 9.9 % of rubber, 33.4 % of organic waste, 9.2 % of other bio-degradable waste, 2 % of hazardous hospital waste and 17.9 % miscellaneous waste.
A study conducted by TIDE\textsuperscript{65} analyzed and compared chemical characteristics of waste sample drawn at source with samples drawn at dump site of Bangalore city solid waste. The moisture content at source and dumpsite was found in 2001 as 30.17 % and 33.21 % respectively. Similarly total nitrogen content was 1.09 % and 0.82 %. The organic matter accounted for 43.01 % and 61.68 %. Organic carbon accounted for 24.94 % and 35.72 %. The calorific value stood at 466.11 cal/kg and 369 cal/kg. Total ash content stood at nil and 38.23 %. The report stated that the average bulk density of municipal solid waste and market waste as measured in waste collection / transport vehicle was found to be 0.325 t/m\textsuperscript{3} and 0.463 t/m\textsuperscript{3} respectively.

AUSAID\textsuperscript{66} examined an overall assessment of present practices and services for the management of municipal solid waste in Bangalore including the surrounding municipalities. The objectives of the study were to investigate and report on alternative strategies for the development and improvement of solid waste services in Bangalore City. The findings of the study suggested that the source segregation of the municipal solid waste was the most preferred policy for minimization of waste generation and the improvement of solid waste services. To achieve that, it was recommended to develop an alternative community education and information program and to provide door-to door waste collection service to all domestic premises.

Farruk Ghani\textsuperscript{67} attempted to analyze the solid waste management issues and current status in medium sized cities of India. In 2002, it was estimated that in the medium sized cities (about one million population) a solid waste of about
0.73 kg per capita per day was generated. Only 60 –70 % of the waste generated was collected in the cities by the boards / corporations. The boards/ corporations spent 35 % of the annual budget of the corporations on waste disposal alone. The volume of waste transported was about 300-350 cubic meter per million-population everyday. The average organic and inorganic contents of solid waste generated in medium sized cities were found to be 55.22 % and 44.78 %, respectively.

4.16 Parthasarathy K.T, Manamohan Rao, et. al tested the optimization of solid waste collection and routing by the application of remote sensing and GIS technique. A study was conducted in one of the wards of Bangalore city. The work involved locating proper collection points of waste, optimizing the number of collection points, routing of collection vehicles and considering the type and capacity of vehicles. The necessary database required for GIS were population in the ward, per capita solid waste generation, ward map, collection vehicle capacity and mileage.

4.17 Philip O Leavy and Patrick Walsh in his article on “The Problem of long-term post closure landfill care - Is 30 years long enough?”, made an in-depth analysis on anticipated problems on post closure landfill care after 30 years (life period) and concluded that to design and operate a landfill in a manner that reduces the intensity of long term care activities, he emphasized to segregate or remove most of the organic material from the waste before it is landfilled. The segregation and removal of organic matter would reduce the greenhouse gases that result from landfilled gas emissions. The unsegregated
organic matter in landfill on decomposition would lead to primary contaminant leachate and methane. The study also revealed that the European Union, through order 99/31/EC mandated a significant reduction of landfilled organic materials: To reduce up to 75% in 1995, 50% by 2013 and to 35% of total organic content experienced in 1995 by 2020.

Section V: Alternative methods of waste recycling and waste disposal

In this section, findings of research studies pertaining to alternative methods of recycling and waste disposal are reviewed.

5.1 Warren Snow and Julie Dickenson in their paper on “Zero Waste Philosophy” have strongly advocated zero waste as a new way for creating economic wealth and addressing a host of social and environmental problems. They highlighted the role of each stakeholder in implementing and achieving zero waste movement. The Government has to take the leadership role and develop legislation to support. The local authorities to guard community ownership, implement legislation and to enter into partnership with community and private sector to devise local resource recovery. Households to buy products that are durable, repairable and recyclable. Universities and schools to teach zero waste principles as part of their basic curriculum. Manufacturers to invest in new design to create products with minimal waste, reduce packaging to a minimum and take responsibility for both recycling or reuse of packaging and product. The study concluded suggesting core principles to ensure success, which included: i. end cheap waste disposal, ii. design waste out of system and iii. engage the nation.
5.2 Bill Sheehan, Daniel Knapp\textsuperscript{21} stressed that the key factor in making progress towards the zero waste vision in their article “Zeroing In On Zero Waste” was that the corporation shares the responsibility for wasting and recycling. It was suggested that the business and industry to redesign products for zerowaste and to develop reverse distribution systems to take product back into production rather than dumping the problem on community landfills and incinerators. Promotion of the idea that waste equals inefficiency is likely to make people less contributing to solid waste generation. It was concluded that rules and laws should be changed or amended to reward resource conserving behavior and the items that cannot be safely recycled at any reasonable cost should be banned.

5.3 Marti Matsch\textsuperscript{22} advocated Zerowaste. He explained in his article on “Zero waste –A New System Approach Gaining Global Ground”, that recycling alone cannot end the dependency on landfills and incinerators, nor reverse the rapid depletion of our natural resources. As world population and consumption is rising, the one way system of extracting virgin resources to make packaging and products that are latter buried or burned was not sustainable. He observed that American companies doing business overseas are already redesigning their products and manufacturing processes to meet the zerowaste standards adopted by other countries. If it could be done for overseas business, he stressed that it can be done for local business too. The suggestions put forth by him for achieving zerowaste were: i. true cost accounting i.e. to include the cost of environmental degradation and public health impacts associated with the virgin resources extraction, processing, manufacturing & disposal of that
product. ii. redesigning products and packaging for durability, reuse, and recyclability, iii. creating jobs for the discards and iv. investing more in infrastructure than in landfills.

5.4 Eric Lambordi71 in his article on “Beyond Recycling-Zero Waste -Or Darn Near” has highlighted the concept of zero waste. He observed that despite the fact that more than 100 million Americans are recycling in 2001, the wasting rates in United States were climbing up. He explained that recycling was only an end-of-pipe solution to a problem. Waste is not envitable rather it is result of bad design. He explained that zero waste has five basic tenets, which are: i. Redesigning products and packaging, which involves planning in advance to limit resource consumption, toxicity and waste; ii. Producer responsibility where manufacturers are held responsible for the waste and environmental impact their product and packaging creates; iii. Investing in infrastructure rather than using the tax base to build new landfills and incinerators; iv. To end taxpayer subsidies for wasteful polluting industries; v. To create jobs and new business from discards. It was reported that wasting materials in landfills or incinerators also wastes business opportunities that could have been created if those resources were preserved. It was concluded that zero waste could help in creating new positive alternatives to depleting natural resources.

5.5 Robin Murray74 emphasized that the incineration was a technology of the previous industrial era and supported for recycling and zero waste. Incineration carries an inherent tension between internal and external costs. Incineration also produces hazards and toxic emissions. The emissions of acid
gases, dioxins and furans have led to widespread protests in North America, Japan and continental Europe, forcing the closure of plants and abandonment of plans for new ones. In 1991, it was found that in Japan, only eight of the 1500 operating incinerators met international dioxin standards. In Germany 1 million people signed petitions against incinerators. In France, a Government survey of incinerator emissions in 1998 led to the closure of twenty incinerators and probation for others. Milk produced near an incinerator in north of Paris was found with high level of dioxins. In the UK, it was reported abnormal rates of cancer for people living near incinerators. It was concluded that incineration does not lead to material conservation and hazard reduction but material destruction and hazard creation. It was estimated that 1 % increase in recycling in the US would reduce carbon dioxide emissions by an amount equivalent to taking 1.2 million cars off the road. The study suggested to adopt zero waste policy.

5.6 The report of the Committee\textsuperscript{75} constituted by the Hon. Supreme Court of India advocated the need for effective public awareness campaign to reduce the generation of waste in the first place and consider ways to re-use and recycle the waste, so that the least quantity of waste needs to be processed and disposed off. The report suggested various measures to bring a change in public behavior, which were involvement of professional communicators, use of hoarding, paintings on public transports, use of cable TV and cable channels, use of radio and T.V, use of newspaper, NGO involvement, use of schools and colleges, use of ward committees, use of NCC, NSS, Scouts and
guides, street committees and resident associations, involving commercial sponsors and organizing awareness camps and literacy programs.

5.7 David Davies in his paper on “Exploding some myths- smoke and mirrors in waste management performances”, emphasized that no city or metropolitan area can achieve municipal waste recycling / composting rates above 60 %. The best performing cities achieve typically in range of 40-45 %. He explained that a target of 45% would be more realistic when coupled with other policy measures, which includes substantially higher landfill rates, direct householder charging for residual waste and landfill bans.

5.8 John Austin-Davies in his paper on “Refrigeration Waste - What now, What next?”, stressed that the manufacturers of electrical and electronic products should take the end of life of a product into account within the basic design. He emphasized that the producers of the products should provide disposal facilities for its product using authorised operators. It was reported that United Kingdom (U.K) has passed directives known as Waste Electronic & Electrical Equipment Directives (WEE) with the aim to ensure that the waste stream from electronic & electrical goods could be easily separated and treated for recycling and it has set an initial target of 4 kg / person to be reclaimed each year.

5.9 Frank Kelett in his article entitled “Making the most yesterday’s news – Newsprint recycling and the Australian news industry”, made an in-depth analysis on old newspaper and magazine recycling. He found that Australia
has been spectacularly successful as a nation in raising rates for collection of old newspaper from an estimated 28% in the start of 1990 to 72.4 % in 2002 in a span of 12 years. The main reason behind the success was found to be the publisher / newsprint producer partnership as single largest entity purchasing old newspaper and magazines. The formation of a publishing industry as a wide body to draw up voluntary agreements represents a considerable success for the concept of extended producer responsibility. It was reported that old newspapers were used for export, conversion into cardboard, domestic insulation and egg cartons.

5.10 Robert Eden, Omer Salman and Loannis Frantzis\textsuperscript{79} in their article on “Predicting Potential – Landfill Gas Utilization in Turkey”, made an in-depth study on feasibility of installing and operating landfill gas as energy resource or energy recovery from waste landfills. They found that a prime requirement for any landfill gas utilization scheme was a reliable prediction rate of gas production rate. They estimated that between 6 m\textsuperscript{3} and 10 m\textsuperscript{3} of landfill gas would be produced per tonne per year for 10 to 15 years from placement. They identified 10 necessary parameters as a prerequisite before to construct gas prediction from landfill sites. They concluded that if methane level falls below 30 %, the gas becomes more difficult to use, thus unfeasible to utilize landfills.

5.11 Dua Neha\textsuperscript{80} in her article, “Honey, Who shrunk the plastic”, reported that plastic can be biodegraded within a month. It was found that addition of small amount of sugar with Maleic acid could make plastic more ecofriendly.
5.12 Sambandan V.S. has examined and analyzed the issue of plastic ban in Tamil-nadu. The reasons to put such a legislation were stated as, rising composition of the plastics in the municipal waste, the non-biodegradable nature of the material, the ubiquitous role the plastic occupied in the modern society and the health implications of the disposal techniques. Besides Government decision to ban, several local bodies have put a ban in place, made the task easier. The islands of success at Udhagamandalam (Ooty) or pilgrimage center like Thiruvannamalai, the key input has been support extended by the local population that view their communities as those that require protection from the throw away practices by the visitors. It was found that for an effective countering the practice of throw away plastics, the cooperation of a critical mass of the people and non-governmental organizations are essential.

5.13 Mini Shrinivasan in her article “Conservation through Waste” presented a case study of Pune waste pickers. She observed the formation of Union of Waste Pickers had given the waste pickers a new life and voice in society. The issuing of identity cards (ID) by Pune and Pimpri Chinchward Municipal corporations, (which was first of its kind) as demanded by unions, had an immense psychological effect on the waste pickers. The association is instrumental in taking a clear stand against the practice of the child labour in the sector. Their association and recognition with ID cards not only brought a feeling of support from outside but also proud to walk hand in hand with other citizens.
5.14 Jamwal Nidhi\(^3\) reported that burning of waste with reference to bio-medical waste was being discouraged the worldover because of the release of the cancer causing carcinogenic chemicals like dioxins and furans from chlorinated waste. The small scale incinerators (the capacities which varies from 4 kgs/hr–40 kgs/hr) operate at temperatures of 650-800 degree centigrade, which are too low for complete combustion of waste. The small-scale incinerators are not within strict environmental parameters. It was suggested that under non-burn technologies, waste should be disinfected at high temperatures, shredded and then recycled. Microwave, autoclave and hydroclave are some of the variants of these techniques. For rural areas, it was suggested that autoclaving was preferable since the volume of immunization waste is not very high.

5.15 Baud & Schenk\(^4\) conducted a survey on waste pickers through interviews and found that in India the waste pickers mainly belong to lower social stratum. The survey revealed that far more women than men undertake waste picking and most of the males were boys. The waste recovered by waste pickers includes any material of resalable value and commonly includes paper, cardboard, textiles, glass and wide range of plastics and ferrous and non-ferrous metals. From the interviews conducted with waste pickers, it has been established that other materials recovered include wood, coconut husks, animal bones and hair. It was estimated that there were approximately 600 dealers in Bangalore, of which many belong to Muslim community.
5.16 AUSAID\textsuperscript{85} has estimated in 2001 that approximately 600 tonnes of waste, which is nearly 40 \% of the total quantity of municipal waste generated in Bangalore city were disposed each day by open and uncontrolled dumping on the road side. It was reported that the waste was found to be dumped at various locations on the outskirts of the city at Magadi road and Mysore road to the west of city center, Tumkur road and Hennur main road to the north, Airport road and Old Madras road to the east and Hosur and Kanakapura road to the south of the city.

5.17 Raghnath Reddy R.L., et.al.\textsuperscript{86} in their research paper titled “Physical Biochemical Characterization of Solid Urban Waste-Bangalore City”, studied the nutrient composition of urban waste. Their findings suggested that urban waste was one of the potential nutrient organic residues, which on recycling yield valuable and nutrient rich product as compost. It was reported that urban organic waste was alkaline in nature (pH= 7.76) and fairly low in N (0.76 \%), P (0.04) and fairly rich in K (0.54 \%). The organic carbon was 42.46 \% with C:N ratio of 55: 86. The findings also revealed that if the solid urban waste was let out without recycling, large quantities of plant nutrient get washed away, which constituted about 15200 kgs of nitrogen, 800 kgs of Phosphorus and 10800 kgs of Potassium. The study concluded that bio-remedial recycling of solid urban waste would meet a part of agricultural input in terms of nutrient value and also acts as source of organic matter, which is considered as “the life of soil”.
5.18 Jagannath, V., et al., developed a criteria for validation of environmental sound technologies for urban solid waste in Indian context. Seven optional technological sub-systems namely vermicomposting, bacterial composting, sanitary refill, fuel pellet, boiler fuel, biogas and mushroom growing had been validated. The conceptual model was primarily based on operational treatment plants and their working parameters viz. minimum size of units, volume of garbage handling, holding time, useful mass through put, quality of waste input, labour and capital cost. It was suggested that suitable technologies need to be evaluated on the basis of: i. overall capital needed and ability for gradual adaptation; ii. overcoming / improving present methods of bin collection; iii. transportation over long distance; iv. labour intensity of the option; v. small economical viable unit; vi. availability of infrastructure, land etc. The inferences were made in typical four subsystems as vermi- composting minimum size 1mx 1m x 0.3m, volume of waste treated 0.3 cu.m/day, minimum viable size 0.25 tonnes/day, useful mass throughput 0.25 by dry wt, holding time 15 + 25 days, labour employed 2 man days, value of product Rs 2000-5000 per tonne. Similar inferences were made for bacterial composting, fuel pellets, and mushrooms.

5.19 Farrukh Ghani and Masroor Alan in their research paper on “On Site Use of Regenerated Demolition Debris in Indian Cities” attempted to assess a safe and economic use of debris concrete as structural grade concrete, a supplementary material for housing industry. The conversion of a large amount of available demolished waste into an alternate source of building material will contribute as a solution for growing problem of waste disposal
and conserve the resources by extending life of existing quarries. It also leads to reduce the rate of consumption of space in landfill sites. The study showed that the demolished debris in Indian cities generally consist of concrete, reinforced steel, masonry bricks, masonry mortar, ceramic tiles, metals, asphalt, wood, plastics, glass, paper and insulation materials. Tests were conducted to assess the comprehensive strength, workability and density of concrete using demolished waste for partially (20%) replacing cement using a mix of ratio 1:2:4. The study concluded that the workability and strength decreases marginally with the addition of demolished waste upto 20%.

5.20 A study by Rakesh Kumar A.A, Chandarkar, et.al. developed a bioreclamation of solid waste dumpsite in Mumbai. The study proved that a municipal dump site could be transformed from a highly unacceptable zone to aesthetically pleasing, environmentally sustainable area in 1.5–2 years. The study was carried out in one acre of land Chincholi (Mumbai) dumpsite on an experimental basis. The emphasis was to establish the plant use for remediation of solid waste with a view to improve the site, bring back ecological diversity, reduce air pollution and provide an integrated method of municipal solid waste dumpsite. The methodology used in the study was based on the preparation of dumpsite selection of plant species and plantation technique. The study concluded that the sites used for municipal solid waste landfill could be easily transformed into acceptable site with many beneficial impacts. The plant species, which showed good and luxuriant growth were Azadirachta indica (Neem), Acacia auriculiformis (Australia acacia), Ceiba pentandra (Cotton tree) Delonix regia (Gulmohr) and Samanea saman (Rain
The study recommended that many sites which are operating at present in the city can implement bio-reclamation with a view to reduce air pollution, stabilization and high aesthetic values.

5.21 Kannan, N and Rajakumar, A, et al. conducted research studies on the use of solid agricultural waste such as fuel wood waste and cashew nut shells in Sivakasi district of Tamil Nadu. Agricultural waste was pyrolysed to get Indigenously Prepared Activated Carbon (IPAC). These IPACs are employed as adsorbents for the removal of heavy metal ions. The results of the study revealed that IPACs could be employed as low-cost adsorbents as alternatives to commercial activated carbon for water treatment processes, especially for the removal of heavy metal ions. The end product IPACs after treatment process is also reusable for construction works as fillers i.e. for roads and building works, due to their mechanical stability.

5.22 Ravi Agarwal and Sanjay K. Gupta conducted a case study and analyzed the problems and issues of the sanitary workers (waste pickers) in Delhi. It was reported in 2002 that there were 90,000 to 1,00,000 waste pickers in Delhi alone. They recover approximately 10 to 15% wastes from different sources, nearly 1000 tonnes of recyclable. 97.5% of those surveyed were migrants who came for employment. Only a few local waste pickers were involved in this job and they admitted that they are ashamed and hate doing that job. The reason was that their relatives, neighbors and acquaintance would strongly disapprove and they would be socially ostracized. The study revealed that the women waste pickers do not go alone for waste picking due to the harassment
by police, their mothers or other women usually accompany them. 24.5 % of the waste pickers were women and another 24 % are girl children below the age of 15. Only 6 % of the waste pickers were found to be of general caste and the rest are from lower socio-economic caste. Only 56 % of waste pickers share food and lend money amongst themselves, which indicates that only half of their population has close interaction among themselves. 70 % of waste pickers are dependent on waste dealer for different kinds of needs and protection (borrow money, stay at dealer’s place, and take offered money). The most important form of patronage relationship that exists between waste pickers and dealers was shelter. It was found that a waste picker on an average earns between Rs 45 and 80. A waste picker with cycle earns around Rs 50 to 80 and those with a tricycle earn around Rs 150 to 200.

5.23 In her article on “Invisible Helpers of the society: Solid Waste Collectors”, Hanspriya Salaria\(^2\) presented the investigations of socio-economic survey in Jammu City (J& K) based on set of questionnaire for various waste collectors viz. rag pickers, itinerant waste buyers (IWB), waste dealers, small enterpriser middleman (SEM) and wholesaler waste dealer (WWD). The survey of the ragpickers revealed that in 32 % ragpickers, more than four family members were involved in this business. 82 % of ragpickers belong to other state. 100 % of SEM and WWD were found to be resident of Jammu. On an average a ragpicker collects 1- 25 kg of usable items viz. paper, plastic, metal and glass from waste per day, whereas WB collects 15-20 kg of waste. The analysis also revealed the percentage frequency of illness as occupational hazard. It was found more in case of SEM and least in case of ragpickers. The study
recommended that housewives to keep two bins for segregated organic and recyclable waste. Ragpickers after segregation of waste should not to throw left over material on roads.

5.24 Deepa G.B, Chanakya H.N, et.al. introduced a Solid - State Stratified Bed (SSSB) fermentor to treat solid waste as a means of resource recovery. The main objective of the study was to determine the potential of SSB technique as a possible solution to decentralize treatment of MSW in small-scale plants operated with simple operating procedures. In the study, 6 kgs of dry leafy biomass were used. Gas production rate of 1.5 – 2.0 m³/m³ reactor volume/day was obtained under ambient condition. The study concluded that performance of SSB reactor was satisfactory. The study showed that SSB reactor could be used both for fresh as well as dry biomass fed stocks to generate biogas. The study suggested the potential capability of SSB bio-reactor to decompose other biomass feed stocks like urban solid waste, weeds, kitchen waste, agroresidue, etc. with similar performance level.

5.25 Satish. R, Sunil Kumar. M in their article on “Policy and Legislative Interaction for Better Solid Waste Management” advocated in favour of the concept of Extended Producer Responsibility (EPR). The success and achievement of EPR of developed countries were analyzed. It was reported that in India MSW rules target municipal authorities, manufacturers of plastics and the citizens. It does not target the producers of goods for which these packaging materials are used. It was advocated that one of the ways to include producers into waste management was through extended producer
responsibility as being done currently for lead acid batteries under the Battery (Management & Handling) Rules 2001. EPR requires that producers either take back spent products and manage them through reuse, recycling and remanufacturing or delegate the responsibility to third party so-called Producer Responsibility Organization (PRO), which is paid by the producer for spent product management. It was reported that by placing responsibility for waste management with producers could lead to create a strong incentive for them to redesign products aiming towards less material use and improved recyclability. The study concluded that there is a greater need to make legislative changes or frame new laws to incorporate the concept of EPR.

5.26 Parthasarathy K. T, Shylaja Shivaram, et.al..95 attempted to assess the suitability of the landfill site in accordance with the criteria notified by the Ministry of Environment and Forest (MoEF) at Hennur Quarry, which was identified by Bangalore Mahanagar Palike. The suitability assessment of the landfill was done with the help of remote sensing and other supplementary data. The results had shown that the Hennur quarry comply with all the criteria. The parameters, which were not satisfied by the quarry, include life of landfill, proximity to habitations and major district road among others. Certain remedial measure were suggested which included acquisition of land within a radius of 500 m around the landfill site, declaring the land as "No Development Zone", prohibiting trespassers and development of greenery around the landfill site.
5.27 Nickolas J. Themelis in his article on “An Overview of the Global Waste-to-Energy (WTE)”, reported in 2003 that in worldwide about 130 million tonnes of municipal solid waste are combusted annually in over 600 waste-to-energy facilities which produces electricity and steam for distinct heating and recovered metals for recycling. In 2003, there were 35 nations having WTE facilities. In 1995, the United States (US) has promulgated Maximum Available Technology (MAT) regulations by US EPA in which the US WTE industry spent more than one billion dollars in retro-fitting pollution control systems and became one of the lowest emitter of high temperature process. The US EPA affirmed that WTE plants in the US produce 2800 MW of electricity with less environmental impact that almost any other source of electricity. The study calculated the amount of green house gases emitted from landfills. For every tonne of waste landfill, emission of greenhouse gas in the form of carbon dioxide increases by atleast 1.3 tonnes. It was concluded that there have been significant advances in WTE technology in last few years than conventional landfills.

5.28 The relationship between compost or organic fertilization and mitigating global climate change was observed by Enzo Favoino, Attilio Tornavacca et.al. It was reported that over a period of time the compost promotes a build up of carbon inside the soil and this could prove to be a powerful sink of carbon sequestered inside the soil. It was calculated in 2003 that 2 giga tonnes per year of carbon are captured in the organic matter of the earth soil. This amount can be compared with the 8-giga tonnes per year of anthropogenic carbon emitted to the atmosphere. The organic fertilization, as good source for
supply of nutrient can imply the potential displacement of chemical fertilizers and associated savings in the energy and fuels for their productions. The study suggested to provide subsides to farmers to use compost in depleted soils with the aim of fighting desertification and promote locking up of carbon in soils.

5.29 Hans-Perter Fahmi in his article on “Understanding Good Waste Management Practices” has explained that from a scientific point of view, almost all the knowledge required for good waste management practices was available. The properties of different types of waste are known and documented. The different process for recycling and treating these wastes are understood, and testing procedures for the waste for land filling have been developed. In industrialized countries and Western Europe, the cost of waste management in 2002 was 0.5 % of the Gross National Product. The cost of urban solid waste disposal (i.e. cost of collection, transportation and recycling and cost of treating the mixed waste) are about US $1-2 per person per week. He explained the problems faced by the developing countries in waste management. As their economies are in transition, waste management usually has a low priority on the political agenda, as they are struggling with the other important issues such as hunger, health problems, water shortage, unemployment and even civil war. He suggested that the resource management as the key aspect for the waste management.

5.30 In their article “Management Principles for the Coming Age of Zerowaste”, Susan Kinsella and Daniel Knapp have presented the zerowaste as a new vision for a new millenium in the field of waste management. They pointed
out the beliefs and value that support a zerowaste movement. It was advocated that zerowaste requires preventing rather than managing waste. It can turn discarded resources into jobs instead of trash. It can emulate natural system where everything that wears out or dies become food or shelter, however temporarily for something else, giving rise to vibrant yet efficient flow of energy and resources. Zero waste visualizes economy as a circular or spiral system in which every part supports and affect every other. It seeks to replace the current outdated linear economic and production system. Two major strategies were suggested for achieving the zerowaste: i. reforming production, construction and consumption to eliminate waste at the source and ii. developing disposal facility that treat all discards as resource to be conserved, not wasted.

5.31 Sushil and Vrat P[100] in their paper on “System Approach to Waste Management”, emphasized to have system approach to waste management i.e. to visualize waste in totality. The increasing technological complexity, capability and wide spread role of techno-socio-economic effectiveness have led to conceive the totality of the problem and devise solution more systematically. It was suggested that the waste management system to be designed in the light of socio-economic environmental and ecological feasibility. A social cost –benefit analysis should be done prior to the implementation of any waste management program. It was suggested to have broad objective and cover all facets of productivity improvements, resource utilization and environment control.
5.32 A comparative study on cost analysis between the centralized and decentralized systems of solid waste management in Bangalore city was conducted by an NGO, Waste Wise Resources Center\textsuperscript{101}. The findings of the study suggested that the cost of the centralized system is more than the cost of the decentralized system. The difference in the cost was attributed due to the difference in the cost of manpower as the corporation workers were paid more than the waste pickers. The DSWMS (Decentralized Solid Waste Management System) could cover the cost only if the cost per user was Rs 15 per month. The cost of external transport was reduced by one-third in the DSWMS. The remuneration paid to the contractors of corporations were much more than the requirement. The quantity of the waste estimated by the contractors was two and half times of the actual quantity generated. In DSWMS, the contractor was paid on the basis of the number of households and quantity of waste generated by each household. The other social benefits in DSWMS were such as the waste was used properly and converted into useful material, increased employment and additional services were provided to residents at a price.

5.33 A case study with title “Community Participation in Solid Waste Management at Sukamantri Kampong Community in Majalaya city, Indonesia”, was conducted by Darmaastuti RR Lorina.\textsuperscript{102} The study revealed the key issues for community participation in solid waste management. The study concluded that the community’s responsibility for solid waste disposal and protection of environment can be increased by creating awareness on the environment, providing the economic benefits for the community from the increased income achieved by selling recycled product and recognizing community
empowerment in enhancing the partnership with the Government. The study recommended to create awareness among the residents by change in the behavior with respect to public cleanliness, involve women as intermediaries in awareness raising and as managers of community services, encourage the community to set their own priorities with the Government, and integration of community economic development into the local economy by building partnership with local enterprises.

5.34 Joshi G.V\textsuperscript{103} in his article on “Best Out of Waste”, presented a new technology which is called Effective Microorganism (EM) technology to manufacture compost out of garbage. The technology was tested and being used at Auroville in Pondicherry and Uralikanchan near Pune. The EM technology instantly neutralizes the bad odour of garbage, reduces the fly menace and suppresses the production of methane gas, thereby preventing fire. It aids in quick decomposition of garbage into compost. The EM technology was used in over 80 countries and prepared in over 40 countries. The EM solution was manufactured in India at Dehradun, the capital of Uttaranchal state. The technology was based on the principle of introducing group of beneficial microorganisms to improve the soil condition, suppress putrefying (disease inducing) microbes and improve the efficacy of organic matter utilization by crops.

5.35 Report of United Nation (UN) Commission on Sustainable Development\textsuperscript{104} advocated in favour of promoting and developing the use of indigenous technologies for waste management. It was reported that imported
technologies resulted in reducing private investment potentials. The report concluded that good interactive data was an essential management tool in dealing with solid waste problems, with the aim of developing indicators that can assist waste producers and handlers to optimize their management systems. The report recommended to promote increased synergy between the formal and informal sectors and greater awareness of environmental and health risks from poor solid waste management, which can influence consumption pattern and can improve the application of sustainable policies.

5.36 Almitra H. Patel\(^{105}\) in her paper on *Urban Solid Waste Management: Progress and Prospect for Social, Technical and Policy Improvement*, has suggested 13 point program for solid waste management. The suggestions include, to strengthen city finances by allowing city managers or elected bodies to raise resources, to declare mandatory buffer zones around identified compost plant sites, to promote public-private partnerships through fool-proof payment guarantees through banks, delegation of fiscal powers for those who are assigned responsibility of SWM which can improve grievance redressal, on road efficiency, productivity and cost. To proceed aggressively to compost all city’s waste which can meet India’s annual shortfall of 6 million tonnes of organic manure to drought proof dry land agriculture, reclaim degraded soil and re-vegetate mining overburdens. Finally to train tomorrow’s city managers today for future urban problems and solutions.

5.37 Marielle Snell\(^{106}\) attempted to analyze the future viability of new development in municipal waste management in India through NGOs and Community Base
Organization (CBOs) active participation. It has shown that NGOs and CBOs were essential component of new development in this area. The study conducted in Hyderabad concluded that the future of the municipal waste management depends not only on the effectiveness of local government and the operator of the public services, but also on the attitude of the citizens and on the key role of the NGOs and CBOs to shape and develop community participation. The study suggested: to have a clear delineation of roles in waste collection played by the formal SWM and private waste collection companies: To collect waste at properly scheduled times instead of irregular hours; Awareness campaign to be through written, oral and visual means to ensure that the population understands the significance of source separation.

5.38 Archana Gosh presented a case study on post plague initiatives of Surat in her article on “Management of Urban Environment – A study on Post Plague Initiatives of Surat Municipal Corporation”. The study highlighted the post-plague environmental cleanliness strategies and actions that transformed Surat as the cleanest City in India. The main administrative strategies included decentralization of power, authority and accountability, maintaining strict discipline and upholding good work culture, collective decision-making, technological improvements and private sector involvement. It was reported that good leadership was the hallmark of the program success. An innovative method of grievance redressal mechanism was adopted at ward, zonal level and corporation level. Two types of cards, which are red and white were used for registration of complaints. Complaints were categorized and prioritized to clear within the time framework of 24 hours, 48 hours, 3 days and 7 days. The
study concluded that public support and political commitment were extremely important for successful public policy changes. Also media support plays a dominant role in creation of public awareness and acceptance of change.

5.39 Patel, H. Almitra\textsuperscript{108} reported that the major obstacle for cities in becoming clean cities was the freeze on manpower recruitment in municipalities. It was found in 2002 that the salaries of sweeper were Rs 5000 to 7000 per month, which are higher than skilled worker or college graduate. The high salary was the main cause for freeze on recruitments. The other obstacles were, the inability to reduce 20 – 40 % absenteeism, to ensure a full day work and to enforce a perform or perish culture because of job protection rules in Government and municipal services. The study suggested that the privatization of cleaning services upto 50 % as a remedial solution for the problem of management of urban solid waste.

5.40 Yang Juanxin, Hao Fu, Rusong Wang et.al.\textsuperscript{109} in their article on “Life Cycle Management of Wastes: Options and Strategies”, attempted a life cycle assessment of municipal solid waste to compare the overall cost and environmental burdens for landfill, incineration and ecological engineering. It was shown that ecological engineering method was superior to incineration and sanitary landfill both in environmental and economic profit. It also suggested a framework of ecological engineering for municipal solid waste (MSW), which includes waste minimization, disinfecting, resource-regeneration, industrialization and socialization.
FOOT NOTES


