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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT – I – Sustainable Waste Management – SARA5332

I. UNIT 1

Introduction to Waste Management

Waste and wastes are unwanted or unusable materials. Waste is any substance which is discarded after primary use, or it is worthless, defective and of no use.
The term is often subjective (because waste to one person is not necessarily waste to another) and sometimes objectively inaccurate (for example, to send scrap metals to a landfill is to inaccurately classify them as waste, because they are recyclable).

United Nations Statistics Division

Wastes are materials that are not prime products (that is products produced for the market) for which the initial user has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose.
Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded."

Waste management is a set of activities that include the following:
collection, transport, treatment and disposal of waste;
control, monitoring and regulation of the production, collection, transport, treatment and disposal of waste; and
prevention of waste production through in-process modification, reuse and recycling.
Wastes are -

- generated during the extraction of raw materials,
- the processing of raw materials into intermediate and final products
- the consumption of final products, or other human activities, including municipal (residential, institutional, commercial), agricultural
- special (health care, household hazardous wastes, sewage sludge).

Waste management is intended to reduce the effect of waste on health, the environment or aesthetics. Waste management practices are not uniform among countries (developed and developing nations); regions (urban and rural area), and sectors (residential and industrial)

List of waste types

Municipal waste includes Household waste, Commercial waste, and Demolition waste
Hazardous waste includes Industrial waste
Biomedical waste includes clinical waste
Special Hazardous waste includes Radioactive waste, explosives waste, and Electronic waste (e-waste)

A natural part of the life cycle, waste occurs when any organism returns substances to the environment. Living things take in raw materials and excrete wastes that are recycled by other living organisms. However, humans produce an additional flow of material residues that would overload the capacity of natural recycling processes, so these wastes must be managed in order to reduce their effect on our aesthetics, health, or the environment.
Solid and fluid, hazardous and non-toxic wastes are generated in our households, offices, schools, hospitals, and industries. No society is immune from day-to-day issues associated with waste disposal. How waste is handled often depends on its source and characteristics, as well as any local, state, and federal regulations that govern its management. Practices generally differ for residences and industries, in urban and rural areas, and for developed and developing countries.

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Agricultural waste
Animal by-products
Biodegradable waste
Biomedical waste
Bulky waste
Business waste
Chemical waste
Clinical waste
Coffee wastewater
Commercial waste
Food waste

Composite waste
Construction and demolition waste (C & D waste)
Consumable waste
Controlled waste
Demolition waste
Domestic waste
Electronic Waste (e waste)

Gaseous wastes
Green waste
Grey water
Hazardous waste
Heat waste
Household waste
  Household hazardous waste
Human waste
  Sewage sludge
Industrial waste
  Slag
  Fly ash
  Sludge
Inert waste

Inorganic waste
Kitchen waste
Litter
Liquid waste
Marine debris
Medical waste
Metabolic waste
Mineral waste
Mixed waste
Municipal solid waste
Nuclear waste (Radioactive waste)
Organic waste
Packaging waste
Post-consumer waste

Radioactive waste
  Low level waste
  High level waste
  Mixed waste (radioactive/hazardous)
Spent nuclear fuel
Recyclable waste
Residual waste
Retail hazardous waste
Sewage
Sharps waste
Ship disposal
Slaughterhouse waste
Special waste - hazardous waste
Toxic waste
Uncontrolled waste
Waste heat
Wastewater
Winery wastewater

Generation of waste
Waste minimization
Waste removal
Waste transportation
Waste treatment
Recycling and reuse
Storage, collection, transport, and transfer
Treatment

Landfill disposal
Environmental considerations
Financial and marketing aspects
Policy and regulation
Education and training
Planning and implementation.

ASSIGNMENT
WASTE GENERATION - CALCULATION
Using the provided waste calculator, the students are expected to quantify the waste generated at their house or locality.

The waste hierarchy refers to the "3 Rs" reduce, reuse and recycle, which classify waste management strategies according to their desirability in terms of waste minimization.
The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste;
The waste hierarchy is represented as a pyramid because the basic premise is for policy to take action first and prevent the generation of waste.
The next step or preferred action is to reduce the generation of waste i.e. by re-use.
The next is recycling which would include composting.
Following this step is material recovery and waste-to-energy.
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The key behind the life-cycle of a product is to optimize the use of the world's limited resources by avoiding the unnecessary generation of waste.
Resource efficiency is the reduction of the environmental impact from the production and consumption of these goods, from final raw material extraction to last use and disposal. This process of resource efficiency can address sustainability.

Overview of laws / rules governing waste management in India - Importance of community participation in waste management - Impact on health and sanitation.
In India, the National Environment Policy, 2006 while suggesting measures for controlling various forms of environmental pollution lays emphasis on

- the need for collection
- treatment systems for recycling wastes
- devising measures for environmentally safe disposal of residues.

In India, waste management is governed by various sub-ordinate legislations and the Ministry of Environment, Forest and Climate Change, Government of India (“MoEF”) in conjunct with State Pollution Control Boards of different states (“SPCB”) administer the gamut of waste management regulations.
Indian waste management rules are founded on the principles of

“sustainable development”
“precaution” (measures should be taken to avoid environmental degradation and hazards) “polluter pays” (polluter must bear costs for damages and harm caused to environment by his own acts).

Bio-medical Waste (Management and Handling) Rules, 1998
The Batteries (Management and Handling) Rules, 2001
The E-waste (Management and Handling) Rules, 2011
The Plastic Waste (Management and Handling) Rules, 2011
The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008
Waste means any waste generated in health care processes like diagnosis, treatment or immunisation of human beings or animals, research activities concerning production or testing of ‘biological’
categories of BM Waste such as human anatomical, animal, microbiological and biotechnology, discarded medicines, cytotoxic drugs, incineration ash, chemical related waste.
applicable to a wide array of institutions such as hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, and blood banks
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BMW Rules are applicable to a wide array of institutions such as hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, and blood banks.
BM Waste is (i) handled in a manner not causing any adverse effect to human health and environment, (ii) segregated in containers at point of generation, (iii) handled and disposed off in accordance with prescribed standards.
as per Rule 5(2), all covered institutions are mandated to either set up treatment facilities like incinerator, autoclave, microwave system, or to ensure that all BM Waste is treated at a common waste treatment facility.
An annual return has to be sent in prescribed format by January 31 to SPCB providing details of categories and quantities of BM Waste handled. There is no specific penalty provided and hence, noncompliance will invoke general penalty under EPA i.e. imprisonment of occupier up to 5 years and/or fine up to INR 100,000 (US$ 1574).

The Batteries (Management and Handling) Rules, 2001

The Batteries (Management and Handling) Rules (“Batteries Rules”) was notified to effect a regulatory mechanism for dealing in and disposal of used lead acid batteries and their components.
The Batteries Rules apply to every manufacturer, importer, reconditioner, assembler, dealer, recycler, auctioneer, bulk consumer (like departments, organisations purchasing more than 100 batteries) and consumer.
The scope of duties of each type of entity is provided in detail to ensure collection, recycling, transportation and sale of batteries.
Rule 10 mandates that all consumers deposit used batteries with dealer, manufacturer, importer, assembler, recycler, re-conditioner or designated collection centres.
Further, bulk consumers are required to file half-yearly returns with SPCB.
Rule 6 requires that for importing batteries from other countries for recycling in India, prior customs clearance must be obtained. Additionally, import of batteries will be allowed only upon producing valid registration with Reserve Bank of India and MoEF and providing an undertaking in prescribed

format along with a copy of the latest half-yearly return.
Noncompliance with the BMW Rules also attracts punishment under the EPA whereby the person-in-charge may be imprisoned for up to 5 years and/or fined up to INR 100,000 (US$ 15574).

The E-waste (Management and Handling) Rules, 2011

("E-waste Rules") aim at putting in place an environmentally sound e-waste management system9 by regulating issues of disposal, import and recycling of e-wastes.
The E-waste Rules apply to every producer, consumer or bulk consumer (including factories under Factories Act) involved in the manufacture, sale, purchase, and processing of electrical and electronic equipment or components, along with all collection centres, dismantlers and recyclers of e-waste.
E-waste is defined under Rule 3(k) to mean waste electrical and electronic equipment, in whole or part or as rejects in the manufacturing and repair process which are discarded.
As per Rule 4, the producer of electrical and electronic equipments must obtain authorization from SPCB, and is responsible for collection of e-waste generated in the manufacturing processes or after endof-life as part of extended producer responsibility, setting-up collection centres, financing costs involved for recycling, creating awareness, and maintaining records and filings.
The Ewaste Rules also delineate the responsibilities of collection centres, consumers, bulk consumers, dismantlers and recyclers.
The rules also provide for the manner of storage, transportation, recycling of e-wastes, procedure for obtaining registration, maintaining of records, etc.
Non-compliance with the provisions of E-waste Rules may result in cancellation or suspension of the authorization.

The Plastic Waste (Management and Handling) Rules, 2011

The Plastic Waste (Management and Handling) Rules, 2011 ("PWM Rules") set up a regulatory framework for manufacture, usage and recycling of plastic bags to ensure management of plastic waste.
Plastic waste means any plastic product such as carry bags, pouches, etc. which has been discarded after use or end-of-life.
The rules are applicable to all manufacturers, stockists, distributors, retailers and users of plastic products. Rule 9 mandates every manufacturer of plastic carry bags, multilayered pouches or sachets and every recycler to seek registration with SPCB.
Such registration is valid for a period of 3 years.
Further, in order to ensure that price is paid for usage of plastic, Rule 10 states that no retailer can provide plastic carry bags free of cost.
Further, the PWM Rules detail aspects of plastic bags such as thickness, colour, classification into virgin or recyclable or compostable plastics, and responsibilities of municipal authorities.
There is no specific penalty provided for non-compliance and thus, penalty under EPA will apply as per which the person-incharge may be imprisoned for up to 5 years and/or fined up to INR 100,000 (US$ 15574).

The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008

2008 ("HWM Rules") were framed for regulating generation, storage, reuse, recycling, import, transportation and treatment of hazardous wastes.
India signed and ratified the Basel Convention, 1992 dealing with transboundary movement and disposal of hazardous waste.
The restrictions on cross-border transportation of hazardous waste for purposes of recycling as provided in the Basel Convention are incorporated in the HWM Rules.
Rule 2(l) defines hazardous waste as any waste which by virtue of its physical or other characteristics (described as chemical, toxic, inflammable, reactive, explosive, etc.) causes or can cause danger to health or environment, either standalone or in combination with other substances.
A list of processes generating hazardous waste is identified in Schedule I which inter-alia includes industries engaged in petro-chemicals, oil & gas, petroleum, mines and minerals, zinc, copper, lead

based production, textiles, steel, asbestos, electronic, tannery, etc.

Every occupier of a factory under Rule 5(1) is required to obtain authorization from SPCB, and will be responsible for safe and environmentally sound handling of hazardous wastes generated in the establishment.

Solid Waste Management - refers to the collection, transportation, treatment , final disposal and recycling of solid wastes.

Proper Waste Handling - means the actual waste which is produced by users by industries and which should be collected properly and carefully transported to an appropriate treatment plant in such a way that it is not hazardous to health and environment.

Community - A community consists of people living together in some form of social organization and cohesion. Its member share in varying degrees of political, economic, social and cultural characteristic as well as interest.

Community Participation - is the process by which individuals and families assume responsibility for their own health and welfare and for those of community and develop the capacity to contribute to theirs and the community development. They come to know their own situation better and are motivated to solve their common problems. This enables them to become agents of their own development instead of positive beneficiaries of development aid.

Recycling - is the process of collecting and preparing reclyable materials and reusing the materials in their original form or using them in manufacturing processes that do not cause the destruction of reclyable materials in a manner that precludes further use. Yard waste composting also be added to the above definition.

Municipal Solid Waste Management – Indian Scenario

The Eleventh Planning Commission figures again estimate 70 to 90 % efficiency in urban waste collection in large metros and below 50 % in small towns.

The urban local bodies spend approximately Rs. 500 to Rs. 1500 per ton on solid waste collection, transportation, treatment and disposal.

Nearly 60 – 70 % is spent on street sweeping, 20-30 % on transportation and less than 5 % on final disposal.

The per capita waste generation in urban cities varies from 0.2 kg to 0.6 kg per day depending on size of population and the lifestyle of the people.

It is also believed that the per capita waste generation is increasing rapidly at the rate of 1.3 % per year.

Added to this is an annual increase in urban population resulting in an overall increase of urban waste generation at 5 % per annum.

Urban local bodies are unable to cope with this rapid increase as the management planning for Solid Waste Management is outdated.

The severe lack of funding targeted specifically at solid waste management compounds the problems presently being faced by urban local bodies.

Sources of municipal solid waste

Domestic Waste which includes Household waste- kitchen waste, house cleaning, old paper, packing, bottles, crockery, furnishing materials, garden trimmings etc;

Commercial Waste which waste generated at business premises, shops, offices, markets, hotels, departmental stores (paper, packing material, spoiled discarded goods). These could be organic, inorganic, chemically reactive and hazardous waste;

Institutional waste which is waste generated at schools, colleges, hospitals, government offices, private tutorials etc;

Street sweeping which includes littering by pedestrians, vehicular traffic, stray animals, road side tree leaves, rubbish from drain cleansing, debris; etc

Industrial and trade waste which manufacturing and material processing trade generates;

Construction debris which includes frequent digging of roads by various utilities comprising earth, bricks, stones, wooden logs, etc; and finally

Offal which is generated from slaughter houses, food, packing institutions, and cold storage premises, etc

Current Waste Management Practices

The three important stages in waste management in the formal sector or urban waste management systems in the country are

- waste collection
- street sweeping
- cleaning of public places
- storage and transport
- waste disposal.

Increasingly, this task which is labour intensive is being contracted out to private contractors/ NGOs, who employ labour on a contract basis. In some cities, Resident Welfare Associations (RWAs) have taken the initiative to collect the waste. Apart from door-to-door collection, the local bodies gather waste from the streets through street sweeping; waste from bulk waste generating institutions such as hotels, schools and colleges and waste from bins in market areas. Street sweeping employs the largest number of municipal workers (safai karamcharis/pourakarmikas) and in major cities, they work in shifts, with a night shift being introduced to clean busy roads in business areas and market places.

Primary Collection

In most large cities and towns

waste is collected from dustbins

door-to door collection

other collection points by the local body/municipal corporation from different parts of the city, transported and disposed of in 'landfills' or on land surrounding the city limits.

The approach to waste collection varies across the country and the increasing involvement of the private sector in this activity is discussed later in the report.

Transportation and Storage

The door-to door collection requires equipment for transportation, such as the hand cart or tricycles to collect and transport waste to transfer stations.

These transfer stations could be open air dumps or closed sheds.

Waste is sorted at the transfer stations and large amounts of waste is then transferred to dumping sites in mechanized vehicles such as trucks, tempos or tractors which transport the waste.

It is now mandatory that the transportation of waste be carried out in closed carriers so that the waste does not spill out during transportation.

Carriers such as container carriers that carry the waste bins and dumper trucks are popular within large municipalities.

It must be noted here that Municipal Waste also contains large quantities of medical waste, hazardous waste and other industrial waste.

Though there are separate laws to deal with them, implementation across the country is substandard.

Waste Disposal

Waste disposal poses enormous problems.

As efforts at segregation of recyclables and composting of organic waste by the municipality are non-existent, huge quantities of waste are being dumped on waste lands in and surrounding the city.

Despite laws mandating scientific land filling, these facilities have not been set up.

The other methods available for waste disposal are

- processing/ treatment
- disposal of MSW are composting, vermin- composting, anaerobic

- digestion/biomethanation
- incineration
- gasification
- pyrolysis, plasma pyrolysis
- production of Refuse Derived Fuel (RDF), also known as pelletization and
- sanitary landfilling/landfill gas recovery.

Land filling

Land filling is the most popular method for waste disposal.

Sanitary land filling – which requires the use of technology and effective monitoring – is rarely practiced in the country.

On the other hand, waste is dumped in open, abandoned land, often close to water bodies leading to large scale contamination of surrounding land and ground water sources.

As a large amount of dumping across the country happens on fallow land in surrounding villages, the village local authorities there is growing protest from locals and local bodies in several instances, have refused permission for dumping.

Several conflicts have also erupted as villagers protest wide spread contamination of their land and water sources.

Apart from the health and environmental impact, land filling as a technique requires more and more land to be acquired to keep pace with the generation of urban waste.

Landfills also release methane gas, which is more potent than carbon dioxide, thus contributing to global warming.

It is important therefore to reduce the emission through composting, recycling and reduction of waste generation.

Thus, where land filling is inevitable, it must ensure leachate control and bio-gas utilization to ensure sanitary land filling at its optimum

Compositing

Composting as a method of effective disposal of organic waste is practiced in a few select areas.

Composting is the decomposition of organic matter by microorganism in warm, moist, aerobic and anaerobic environment.

This method is simple, effective, low cost and the compost generated can be sold to farmers in surrounding areas.

Vermi-composting is the natural organic manure produced from the excreta of earthworms fed on scientifically semi-decomposed organic waste.

It requires less mechanization, is easy to operate but it requires careful handling to ensure toxic material does not enter the chain which could kill the earthworms.

Only a few small towns in the country are practicing vermi-composting while some large cities have aerobic compost plants of a larger capacity.

But many of these plants are functioning much below installed capacity.

Waste to Energy

An alternative is converting waste to energy—burning garbage to produce electricity. It involves large capital investment and several government subsidies are on offer to encourage businesses from taking up WTE projects.

The Ministry of Non-conventional Energy has been promoting waste-to-energy projects through two schemes-(a) National programme on energy recovery from urban and industrial wastes and (b) UNDP/GEF-assisted project on development of high-rate biomethanation processes.

WHY COMMUNITY PARTICIPATION IS IMPORTANT?

community participation can effectively target resources and efficiently. This is because through community participation, community willing to share ideas and opinions. It is a way to get know the requirements and needs of the community. Besides that, the provision of resources including money

and time consuming to use the best because everything they do will not be in vain as the support of the community.

Second, it can allow two ways communication and thus participants to give a new ideas. Through two-way communication, the conflicts and information can be delivered effectively.

Third, community participation offers a new thinking and innovative ideas from community. Through the opportunities provided, community will pleasure to voice out their opinion. It will indirectly train the community to think creatively and become more innovative.

Forth, by community involvement in planning and decision making, community will have the responsibility and sense of ownership. As the community will feel that they are also involved in a project.

Fifth, it is a process of empowering people and it is a way to sustainable planning and development.

Community Participation includes

citizen participation

people's participation

public participation

popular participation'

REFERENCES

READINGS

http://bbmp.gov.in/documents/10180/1920333/SWM-Rules-2016.pdf/27c6b5e4-5265-4aee-bff6-451f28202cc8
http://mcrohtak.gov.in/SWMRSN/Solid%20Waste%20Managment%20Rule.PDF
https://www.academia.edu/7863535/Integrating_the_Informal_Sector_in_Waste_Management_IFC
https://openknowledge.worldbank.org/handle/10986/30317
https://unhabitat.org/collection-of-municipal-solid-waste-key-issues-for-decision-makers-in-developing-countries

VIDEO LINKS

https://www.youtube.com/watch?v=1Ovv3yU02UE&feature=youtu.be
https://www.youtube.com/watch?v=DmFGsxLcT6k
https://youtu.be/C2vjsA9xChM

REFERENCES

http://www.concepts.org/index.php?title=Refuse
http://www.basel.int/TheConvention/Overview/tabid/1271/Default.aspx
https://stats.oecd.org/glossary/
https://www.jagranjosh.com/general-knowledge/solid-waste-management-1440680755-1
https://academic.oup.com/bmb/article/68/1/183/421368
http://edugreen.teri.res.in/explore/solwaste/types.htm
https://enviroliteracy.org/environment-society/waste-management/what-is-waste/
https://sg.inflibnet.ac.in/bitstream/10603/250240/11/9.%20chapter-1.pdf
https://www.coursehero.com/file/33735599/doc-9docx/
https://www.mondaq.com/india/waste-management/396342/waste-management-in-india-an-overview/
https://www.sciencedirect.com/topics/earth-and-planetary-sciences/polluter-pays-principle/
https://hspcb.gov.in/BMW%20Rules.pdf
http://www.mppcb.nic.in/proc/Batteries%20(Management%20and%20Handling)%20Rules,%202001.pdf
https://www.meity.gov.in/writereaddata/files/1035e_eng.pdf
http://www.elaw.in/waste/plastic/rules.html
https://www.britannica.com/technology/solid-waste-management
http://www.indiaenvironmentportal.org.in/files/ppp_position_paper_solid_waste_mgmt.pdf
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.504.6165&rep=rep1&type=pdf
http://swachhbharaturban.gov.in/

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DEPARTMENT OF ARCHITECTURE

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II. UNIT 2

Solid Waste Management in India

Rapid urbanization, urban growth and economic development have not only changed the physical size of the cities but is also exerting significant additional pressure on the infrastructural services across Indian cities. India is experiencing high urbanization, currently 31 percent as per Census 2011, contributing to 11 percent of the world population and having 53 metropolitan cities which may jump to 87 in 2031. Urban growth is phenomenal and important for the development of the country but unbridled growth may present a glimpse of chequered pockets of ghettos and high class areas (Gupta, 2015). These factors influence consumption rates that accelerate waste generation and change waste composition. The increasing trends in per capita waste generation puts immense pressure on urban local bodies (ULBs) who are mandated to provide this service in India. It is observed from the recent research that most ULBs are unable to handle such huge quantities of solid waste due to financial and institutional debilities. While, daily collection efficiency is around 50-60 percent and 90 percent in few ULBs, only 10 percent of the collected waste receives treatment and virtually nothing is scientifically disposed in engineered landfills(NIUA, 2013). Indian cities are facing the problem of limited availability of land for waste disposal especially in large cities. Furthermore, the ULBs rarely have sufficient funds, resources, infrastructure and appropriate strategies which have resulted in poor collection, transportation, treatment and safe disposal of solid waste. Recognizing these challenges, the Indian government and key stakeholders have been deliberating upon mechanisms and arrangements to facilitate compliance of ULBs with requirements for treatment and safe disposal of solid waste (MoUD, n.a). The two ministries of Government of India namely, the Ministry of Environment, Forest and Climate Change (MEF&CC) and the Ministry of Urban Development (MoUD) have initiated several policies and programmes to improve the current scenario of solid waste management (SWM) system in India. The Environment Ministry had promulgated the Municipal Solid Waste Management Rules in 2000 which is now being revamped as Solid Waste Management Rules 2015 while the MoUD has prepared a draft manual on MSWM to support cities and towns on planning and implementing a proper MSWM system in line with the SWM Rules being promulgated in 2015. While the MSWM Rules2000 prescribed the manner in which the authorities have to undertake solid waste management activities within their jurisdiction,it was observed that it failed to achieve its objectives due to lack of clarity, awareness among the stakeholders and poor enforcement by the regulators. The present paper is an endeavour to provide a comprehensive review of the solid waste management system and most importantly highlight some major points of the government's policies and programmes required to overcome the challenges of municipal solid waste management in India. The paper has been divided into four sections. Section 1 provides the comprehensive review of the current municipal solid waste management in India including the issues and keychallenges faced by the ULBs in making MSWM more sustainable. Section 2 discusses the technological options available for the treatment and disposal of solid waste. It also highlights the government's incentives and financial supports i.e. grants and subsidies to the ULBs for the improved SWM in the country. Section 3 of the paper provides the comprehensive review of the legal and policy framework for MSWM. The gaps in the SWM Rules 2015 and suggestions on it are discussed in the last section 4 of the paper before a brief conclusion.

Section 1: Current Scenario ofMunicipal Solid Waste Management Solid waste management includes managing activities associated with collection, transportation, treatment and disposal of solid waste in an environmentally compatible manner with due consideration of the principles of economy, aesthetics, energy and conservation. These activities are briefly discussed in the following section: 1.1 Municipal solid waste generation According to the Central Pollution Control Board (2015), India

generated1,43,449 tons per day (TPD)of municipal solid waste during 2014-15, with an average waste generation of 0.11 kg/capita/day (GIZ, 2015).It does not include waste picked up by Kabadiwalas from households and from the streets by rag pickers. Whereas according to the report of the Task Force on Waste to Energy (WtE), (2014) of the Planning Commission, the 7935 urban centres of India generate 1,70,000 TPD i.e. 62 million tons of MSW annually. It is observed that there is conflicting data about the actual quantum of waste generation in urban India because there is no system of periodically collecting data on waste generation.In terms of per capita, the waste generation varies between 200-300 gms/capita for small towns, 300-400 gms/capita for medium citiesand 400-600 gms/capita for larger cities as per the Planning Commission report. The increase in waste quantities has been estimated at 5 percent per annum.It is assumed that urban India will generate 2,76,342 TPD by 2021, 4,50,132 TPD by 2031 and 11,95,000 TPD of MSW by 2050. (Planning Commission, 2014).The physical and chemical characteristics of solid waste vary depending on population size and consumption pattern.As per the report, MSW constitutes 51 percent of organic waste, followed by the inert and non-organic waste at 32 percent. Plastics, paper, and glass constitute 17 percent of waste which are classified as recyclable wastes. The report of the Earth Engineering Centre (2012) stated that the calorific value of the waste taken largely from 7 large metropolises varied between 6.8-9.8 MJ/Kg (1620-2340 Kcal/kg.).Waste from smaller cities have low calorific value mostly less than 800Kcal/kg. It is known that a calorific value of over 2800 Kcal/kg is required for feasible incineration. The report of planning commission highlights that the plastic waste including composites are high calorific value material and crucial ingredient for MSW based WtE plants. Chintan and many other reports show that plastics are the most preferred items for retrieving by waste pickers, from garbage, since they are light weight and plastics like HDPE, LDPE and PP fetch good prices. However, extremely light weight plastics like plastic carry bags or very highly soiled plastics may be left behind in the garbage because of their low price potential. For improving the recycling of plastic waste, the Ministry of Environment, Forest and Climate Change notified "The Plastic Waste (Management and Handling) Rules, 2011" in supersession of the "Recycled Plastic Manufacture and Usage rules, 1999" notified under the Environment (Protection) Act, 1986. This is again being revamped as Plastic Waste Management Rules 2015. "Rule 6 of the said rules mandates that a plastic waste management system be put in place and identifies municipal authority as the agency responsible for implementation of the said rules within their jurisdiction". 1.2 Solid waste collection The latest report of the Planning Commission (2014) shows that as high as 68 percent of the waste generated is collected daily in India while according to the report of MoUD (2011), this percentage varies between the different sizes of cities, i.e. 70-90 percent in larger cities and less than 50 percent in smaller cities. It is observed that the collection efficiency of MSW in cities and towns is low due to non-uniformity in the collection system. Nearly 100 percent collection is observed in only those areas where the private contractors and NGOs are engaged in the waste collection activity. Uncollected waste often lies outside the designated bins in most of the urban areas due to inappropriate design, capacity, location and poor attitude of the community towards using bins. It is observed that the uncollected waste is generally burnt in open areas or on the streets. The report of the planning commission shows that over 81 percent of MSW annually is disposed at open dump sites without any treatment. Are port of Earth Engineering centre shows that "such open burning of MSW and landfill fires together releases 22,000 tons of pollutants into lower atmosphere of Mumbai city every year". It is worthwhile to note that the segregation of waste at the door step is almost absent although door to door waste collection is improving in some cities of India. Recognizing the need to adopt innovative strategies for sustainable solid waste management, many ULBs have started door to door waste collection, zero waste management, and segregation of waste at source in their cities. Success Stories Research documents reveal that 100 percent door to door waste collection has been achieved in 329 cities of Goa, Gujarat, Karnataka, Madhya Pradesh, Mizoram, Nagaland, Odisha, Sikkim, Tamil Nadu and Telangana. It is further proposed in 1000 cities for the year 2015-16. In Goa, self-help groups are involved in the entire Margoa Municipal Council. The Kochi Municipal

Corporation has successfully implemented a bin-less system in a few wards of the city (Manual: MoUD, 2014).

Pune Municipal Corporation (PMC) has initiated door to door waste collection under SWaCH programme. In 2008, the PMC signed a five year Memorandum of Understanding to decentralize door to door collection services for households, shops, offices and small commercial establishments and to allow SWaCH members to carry out this work. As part of its support, the Corporation provides uniforms, aprons, raincoats and shoes for waste pickers involved in door to door waste collection as well as other equipment such as brooms and cycle rickshaws. At present, there are 2,300 waste pickers who collect garbage from 4 lakh properties with an average of 174 properties per waste picker. The Cooperative members collect user charges ranging between Rs.10/- to Rs.30/- per household per month from the service users. The advantage of SWaCH model is that it helps the PMC collect waste from door step, is cost effective, leads to high-resource recovery, is labour-friendly using existing workers and is a sustainable enterprise (NIUA, 2013). In Surat, a door to door waste collection system by a private operator introduced in 2004has been successful. The system is operated on a PPP model with a 10 year concession period. The operator uses closed body vehicles equipped with vehicle tracking system. About 60 percent of total municipal solid waste is being collected and transported by the private operator by using 310 vehicles in the respective zones (Swachh Bharat Newsletter MoUD,2015). The Shimla Municipal Corporation formed a society known as 'Shimla Environment Heritage Conservation and Beautification' (SEHB) in 2009. The scheme was operationalized in April 2010. Personal protective equipment like rain coats, gum shoes and gloves have also been given to all sanitary staff (Bharti, 2013). The challenges of this system is mixing of wet and dry waste along with household e-waste and biomedical waste. Vehicle break-down, foul smell and spillage due to improper collection/transportation and inefficient monitoring of routes and operator are other issues that need to be addressed in Shimla. Another initiative 'Zero Waste' system has been adopted by Pune, Ahmedabad, Namakkal, etc. In Pune, the Zero Waste project at Katraj ward No. 141 was undertaken in association with NGO, Janwani. The Corporation banned open dumping in June 2010 and all disposals are done using scientific processing only. There are five decentralized waste processing plants across the city. PMC has activated a new mobile SMS alert system for timely and effective complaint redressal regarding garbage containers. The sustainability of this system relied on household and commercial properties for the segregation of waste. This type of model is first in India that received ISO certification for solid waste collection and transportation. After successful implementation of this model, it was decided to replicate this model in 20 selected prabhags (electoral ward) in a phased manner. Work on the implementation of the first phase has already begun (Swachh Bharat Newsletter, MoUD, 2015). Ahmedabad has signed Memorandum of Understanding (MoU) with United Nations Centre for Regional Development, Japan towards making Ahmedabad a zero waste city. To achieve this objective, Ahmedabad Municipal Corporation is working closely with Urban Management Centre (UMC) for developing Master Plan, City Sanitation Plan, mainstreaming waste pickers and creating citizen awareness (NIUA, 2013). 1.3 Transfer station and transportation Transfer stations are used where disposal sites are more than 10 km away from the city. To save transportation time and fuel such cities have a good performance record of vehicle maintenance and adequate facilities to maintain large size vehicles and containers. Ramp facility is provided to facilitate uploading of the dumper placer containers directly into a large container at the transfer stations. If there is an issue of suitable land for a permanent station then mobile compactor truck with primary collection vehicles can be used to improve the transportation efficiency of the system (MoUD, 2012). Such stations have been effectively used in Surat, and Coimbatore. There are six transfer stations in Surat and all are operational. Waste collected is transported to transfer stations through private vehicles and finally sent to the disposal site for waste disposal. Containers are fully closed with leak proof doors. The achievements of the transfer station model are (i) the municipal waste received through closed vehicles are dropped into closed containers without secondary handling; (ii) covered leak proof containers prevent spillage of waste on the road; (iii) no permanent

or temporary storage at transfer stations, thus averting the nuisance of flies and animals at transfer stations; and (iv) separate leachate collecting system is provided. Coimbatore Municipal Corporation has four transfer stations namely Peelamedu (200 TPD), Sathy Road (125 TPD), Ukkadam (200 TPD) and Ondipudur
(125 TPD). All these transfer stations are operational. At present, although there are different types and sizes of vehicles used for transportation of waste such as dumper placers/schiff loaders, refuse collector without compactor, refuse collection mobile compactors, mini truck with tipping floor, hook loader/hook lifter, the selection of the type of vehicles depends on various factors such as the quantity of waste, distance, road widths and conditions and process technologies. To save travel time, minimize human errors and improve the monitoring system, many ULBs have installed Global Positioning System (GPS), Geographic Information System (GIS), and Global System for Mobile Communication (GSM) system in their trucks to collect waste from secondary sources for the disposal of waste. The Tool Kit for Solid Waste Management prepared by the MoUD reveals that municipalities like PimpriChinchwad, Hyderabad and Delhi have benefitted from this system. Ensuring the efficiency of 100 percent waste collection is still a big challenge for the ULBs despite these technologies. Another significant challenge is to deal with corruption and lack of commitment in the solid waste transport sector. Section 2: Technologies for treatment of solid waste 2.1 Technologies for MSWM At present, there are a number of processing technologies such as composting, bio-methanation, recycling, refuse derived fuel (RDF), gasification, incineration, pyrolysis, engineered landfills etc., available for the treatment of municipal solid waste. However, each of the technologies may have positive as well negative implications. The selection of suitable technologies depends on the population of a city and quantity of waste. It is important to note that "the biggest constraints lie in separating, collecting and transporting this component to the location where decentralized or centralized large scale composting or biogas generation plus composting can be carried out" (Mani, 2015).Efficiency of recycling and composting is greatly reduced due to the absence of source separation. Research documents show that over 50% of waste collected is biodegradable organic material which can be used for compositing or used for generating biogas. This wet waste must be processed either through biomethanation or composting technology for generating biogas, electricity and compost for use as nutrient and prevent such wastes from reaching the landfill. Reusable and recyclable waste that constitute 18-20 percent of the total waste are not separated because the process of separating them from mixed waste is highly energy and time intensive and is generally not carried out. However, the recycling industries face a number of problems such as (i) these industries being labour intensive, (ii) and the poor quality of recycled products are not compliant with regulatory requirements. Mixed waste can neither be recycled nor composted. The report of the Task Force on Waste to Energy (Vol.I), 2014 reveals that "only 22 states/UTs have set up processing and disposal facilities and the rest of the States/UTs had made no effort till 2013. Of the 279 conventional composting, 138 vermi composting facilities, 172 biomethanation, 29 RDF and 8 Waste to Energy plants reported to have been established many are either closed or underperforming". 2.2 Disposal of MSW Waste dumps or open burning continue to be the principal method of waste disposal in India. These methods are continuous sources of harmful gases and highly toxic liquid leachate. Most of the cities and towns dispose of their waste by depositing it in low-lying areas outside the city without taking precautions. As per the estimates made by the Planning Commission (2014), more than 80 percent waste collected is disposed indiscriminately at dump yards in an unhygienic manner by the municipal authorities leading to health and environmental degradation. Limited availability of land for waste disposal is a major cause of the MSW mess especially in big cities. The position paper on the SWM in India of the Ministry of Finance, 2009 estimates a requirement of more than 1400 sq.km. of land for the solid waste disposal by the end of 2047 if MSW is not properly handled. The draft SWM Rules, 2015 provides criteria for the location of sanitary landfills. "Guidelines for the Selection of Site for Landfilling from the CPCB should also be consulted". Finding new landfill sites is a major constraint including the 'not in my

backyard' (NIMBY) phenomenon. People want a good facility for MSW but not in the vicinity of their households. The NIMBY attitude of the people has made the task difficult for the ULBs with respect to waste storage.

2.3 Financial Supports and Incentives In order to give a push to MSWM in cities, the Central government has sanctioned the 12th and 13th Finance Commission Grants and Funds for the improvement of MSW under flagship projects like JnNURM, UIDSSMT from 2005 onwards and the recent Swachh Bharat Mission (SBM). The 12th Finance Commission had allocated Rs.25,000 crore (Rs.20,000 crore for Panchayat and Rs.5,000 crore for ULBs) for supplementing the resources of the ULBs during the period 2005-2010. Under the 12th Finance Commission (FC), an award of Rs.2,500 crore was made available to ULBs of all class I cities for SWM during the period 2005-10. A substantial incentive grant of Rs. 5000 crore was recommended by the 13th FC for grid-connected renewable energy based MSWM on the states' achievement in renewable energy capacity during April 2010 to March 2014. According to the Tool Kit for SWM (2012),SWM should have been treated as a specific and exclusive project, which requires large capital investment as well as operation and maintenance cost. The estimates of the High Powered Expert Committee of MoUD, 2011 reveals that the per capita investment cost and per capita operations and maintenance cost for SWM both are highest in Class IA cities (Rs.900/- and Rs.269/- per year respectively) as compared to other classes (IB, IC and Class II and Class III) due to the assumption that large cities would adopt highly mechanized systems while smaller cities would adopt comparatively more labour intensive processes while Class III and IV cities would adopt lowest technologies. The Ministry of Environment, Forest and Climate Change also provides financial support of upto 50 percent of the capital cost to set up pilot demonstration plants on MSW composting. The Ministry also extends limited financial assistance for waste characterization and feasibility studies. The Ministry of New and Renewable Energy (MNRE) has designed schemes to promote waste to energy projects. The Ministry also promotes all technological options for setting up projects for recovery of energy from urban, industrial and agricultural wastes. Currently only five pilot projects based on MSW to energy are being supported. Under this scheme, a minimum amount of Rs.2 crore and a maximum of Rs. 10 crore per project are available as capital subsidy. The entire capital subsidy amount is released to the beneficiary's loan account. Some of State governments of Andhra Pradesh, Haryana, Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Rajasthan, Tamil Nadu and Uttar Pradesh have announced policy measures pertaining to allotment of land, supply of garbage, and facilities for evacuation, sale and purchase of power to encourage the setting up of waste to energy projects. Land for the facilities is provided by the ULB at a nominal rent. Although recent announcement by the Power Ministry to purchase power generated from WTE plants at a higher rate than earlier, the cost of monitoring and mitigating emissions and pollutants from such incineration based WTE plants has made them unviable. Greater incentivization and operational support is required for promoting biomethanation based WTE. Swachh Bharat Mission is currently making available Viability Gap Funding (VGF) upto 20% to states and individual municipal corporations. However, ULBs are still not able to raise the rest of 80% investment required for SWM improvement in their cities and towns. Greater convergence of schemes and sustainable models need to be explored. 3. Legal and policy framework for MSWM 3.1 SWACHH Bharat Mission One of the important declaration in the development agenda of NDA government is that of Open Defecation Free India by 2019. The "Swachh Bharat Mission" (SBM) is a major initiative of the Ministry of Urban Development (MoUD), Government of India. It is launched on the occasion of the birth anniversary of Mahatma Gandhi on 2nd October, 2014. The Mission is a national campaign covering 4041 statutory towns to clean the streets, roads and infrastructure of the country. Solid waste management is one of the important components of the Mission. The national government has allocated of Rs.14,623 crore for the SBM for urban areas, of which Rs.7,366 crore is given for the SWM for five years i.e. 2014-2019. While addressing the components of SBM for urban areas, state governments and ULBs are expected to focus on a set of

social priorities and outcomes that define the scope and complexity of the Mission.
3.2 Municipal Solid Waste (Management and Handling) Rules-2000 According to the Indian Constitution, the SWM is a state subject and included in the 12th Schedule of the Constitution (74th Amendment) Act of 1992, ULBs are mandated to provide MSWM. State laws governing the ULBs also stipulate MSWM as an obligatory function of the municipal governments. Despite 15 years of implementation of these Rules, ULBs have not been able to put in place good systems. Wherever the people's representatives along with the people have supported source segregation, door to door collection and eco-friendly friendly treatment of the segregated components in waste, they have been able to solve the issue with regard to processing and disposal of solid waste. At present, the MSW Management and Handling Rules 2000 are under revision by MoEF&CC. The draft revised rules was circulated in 2013 and again in 2015 and will be finalized as Solid Waste Management Rules 2015. It lays down the mandatory functions to be performed by various stakeholders. Significantly, the new Rules not only emphasize source separation of wet, dry and hazardous waste and their separate treatment but specifically Construction and Demolition (C&D) waste for separation and treatment as a separate chapter. Similarly the new Plastic Waste, E-waste, Fly-Ash and Bio-medical waste Management Rules are under revision and will be promulgated in 2015. 3.3 Draft Manual on Municipal Solid Waste Management The Central Public Health & Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, Government of India has prepared a draft manual on MSWM to support cities and towns on planning and implementing a proper MSWM system in line with the SWM Rules being amended in 2015. This manual addresses the all aspects of MSWM namely, planning, technical, institutional, financial and legal dimensions. According to the manual, the MSWM plan should address the five year short term plan and long term periods from 20-25 years. "The five-year short term plan may be broken into specific action plans, covering various aspects such as institutional strengthening, community mobilization, waste minimization initiatives, waste collection and transportation, treatment and disposal and other policy changes as may be deemed necessary". 4. Gaps and Suggestions on the Draft SWM Rules 2015 The MoEFCC published the draft SWM Rules 2015 in their website in May 2015 and requested stakeholders throughout India to send their comments and suggestions. The authors examined the draft SWM Rules 2015 to identify gaps and make suggestions. These are discussed in the following paragraphs. Gaps in the draft SWM Rules 2015 1. Although separate categories have been specified for wet, dry, hazardous and C & D wastes, a separate category for sanitary waste is missing. 2. GPS/GIS system for tracking trucks carrying separated waste needs to be emphasized. 3. Synchronization of secondary storage containers and vehicles with transportation is difficult because traffic congestion and pollution from waste collection vehicles plying during peak hours is an issue. 4. Use of user fee charges need to be spelt out especially for the first mile SWM – payment to waste collectors' collectives for door to door collection, decentralized composting, recycling etc. 5. Horticultural waste needs separate processing. Similarly, prohibiting burning of leaves and garden waste needs emphasis. 6. Compliance criteria for Material Recovery Facilities (MRF) and use of Personal Protective Equipment (PPE) for door to door collection and secondary segregation need to be delineated. 7. Responsibility of processing domestic hazardous waste is left to SPCBs instead of making it mandatory to be transported to regional secured landfills and treatment like TSDFs worked out. 8. Knowhow and technologies are not available with ULBs for bio-mining and bio-remediation and action. This should be done through SPVs after proper EIAs etc.

Suggestions to improve proposed SWM Rules 2015 1. Greater emphasis on recycling is required. ULBs especially smaller ones can easily form cooperatives etc. with waste collectors initiatives and collectives for recycling rather than tie-ups with large companies for setting up incineration plants. 2. Recycling technologies for making structural from plastics or converting waste plastics and non-recyclables to Light Diesel Oil as mentioned in the Planning Commission report 2014 should be delineated and their standards prescribed. This is feasible in smaller ULBs also. 3. Waste to energy

Plants based on incineration are still being tested. For smaller ULBs, the cost of incineration plus pollution control is prohibitive. 4. Much greater emphasis on ULBs working with waste pickers collectives and NGOs for setting up door to door collection of segregated waste, Material Recovery Facilities (MRFs) and secondary segregation while providing Personal Protective Equipment (PPE) to them is required. 5. Sanitary and household Biomedical waste management should have a separate section. Sanitary waste collection from doorstep every two days in red colour bags and transporting sanitary and biomedical waste generated in homes and non-medical institutions to Common Biomedical Waste Treatment Facilities (CBWTFs) should be made mandatory. 6. Flushing of gel based napkins should be banned and separate collection emphasized. It can be said that Draft SWM Rules 2015 are a big step forward but they do not address all the concerns and need to be improved if they have to play an important role in improving waste management and sanitation conditions in our country. Conclusion: Overall, the policy agenda for Sustainable Solid Waste Management (SSWM) needs to drive behavioural change among citizens, elected representatives and decision makers to minimize wastage and littering and maximize reuse and recycling. SSWM is a people management issue and over-emphasis of technological solutions to solving the SWM problem will only delay in realizing good results.

Challenges and opportunities associated with waste management in India

Introduction

Solid waste management (SWM) is a major problem for many urban local bodies (ULBs) in India, where urbanization, industrialization and economic growth have resulted in increased municipal solid waste (MSW) generation per person . Effective SWM is a major challenge in cities with high population density. Achieving sustainable development within a country experiencing rapid population growth and improvements in living standards is made more difficult in India because it is a diverse country with many different religious groups, cultures and traditions.

Despite significant development in social, economic and environmental areas, SWM systems in India have remained relatively unchanged. The informal sector has a key role in extracting value from waste, with approximately 90% of residual waste currently dumped rather than properly landfilled . There is an urgent need to move to more sustainable SWM, and this requires new management systems and waste management facilities. Current SWM systems are inefficient, with waste having a negative impact on public health, the environment and the economy . The waste Management and Handling Rules in India were introduced by the Ministry of Environment and Forests (MoEF) , although compliance is variable and limited.

This paper reviews the challenges, barriers and opportunities associated with improving waste management in India. It is the output from an international seminar on ‘Sustainable solid waste management for cities: opportunities in SAARC countries' organized by the Council of Scientific and Industrial Research-National Environmental Engineering Research Institute (CSIR-NEERI) and held in Nagpur, India in 2015. SAARC is the South Asian Association for Regional Cooperation and includes Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka and Afghanistan.

Waste generation in India

India is experiencing rapid urbanization while remaining a country with physical, climatic, geographical, ecological, social, cultural and linguistic diversity The population of India was 1252

million in 2013, compared with 1028 million in 2001 Population growth is a major contributor to increasing MSW in India.

Growth of mega cities in India

Megacities are a relatively recent phenomenon, associated with globalization of the economy, culture and technology Megacities in India include Ahmedabad (6.3 million), Hyderabad (7.7 million), Bangalore (8.4 million), Chennai (8.6 million), Kolkata (14.1 million), Delhi (16.3 million) and Greater Mumbai (18.4 million []. These have dynamic economic growth and high waste generation per capita,

Infrastructure development for public health and protection of the environment

Improvements in civil infrastructure are required for India to become a world leading economy. Developing high-quality infrastructure that meets the needs of the people and protects the environment is fundamental to achieving effective economic growth . Waste management infrastructure has an important role in delivering sustainable development. Rapid population growth in India has led to depletion of natural resources. Wastes are potential resources and effective waste management with resource extraction is fundamental to effective SWM. Value extraction from waste can be materials, energy or nutrients, and this can provide a livelihood for many people The transition from wastes to resources can only be achieved through investment in SWM as this depends on a coordinated set of actions to develop markets and maximize recovery of reusable/recyclable materials . Materials, energy and nutrient recovery must be the aim of future SWM infrastructure development in India. Resources can be recovered from wastes using existing technologies and India has an extremely effective recycling tradition. The ‘scrap dealer’ systems produce recycled materials through an extensive and well-coordinated network across the country.

Statistics on waste generation and waste characterization data

Estimating the quantity and characteristics of MSW in India and forecasting future waste generation is fundamental to successful waste management planning . The quantity of MSW generated depends on living standards, the extent and type of commercial activity, eating habits and season . India generates approximately 133 760 tonnes of MSW per day, of which approximately 91 152 tonnes is collected and approximately 25 884 tonnes is treated MSW generation per capita in India ranges from approximately 0.17 kg per person per day in small towns to approximately 0.62 kg per person per day in cities .

Waste generation rate depends on factors such as population density, economic status, level of commercial activity, culture and city/region. Figure 1 provides data on MSW generation in different states, indicating high waste generation in Maharashtra (115 364–19 204 tonnes per day), Uttar Pradesh, Tamil Nadu, West Bengal (11 523–15 363 tonnes per day), Andhra Pradesh, Kerala (7683–11 522 tonnes per day) and Madhya Pradesh, Rajasthan, Gujarat, Karnataka and Mizoram (3842–7662 tonnes per day). Lower waste generation occurs in Jammu and Kashmir, Bihar, Jharkhand, Chhattisgarh, Orissa, Goa, Assam, Arunachal Pradesh, Meghalaya, Tripura, Nagaland and Manipur (less than 3841 tonnes per day).

Waste characterization data

The local economy impacts on waste composition, as high-income groups use more packaged products, resulting in higher volumes of plastics, paper, glass, metals and textiles. Changes in waste composition can have a significant impact on waste management practices . MSW may also contain hazardous wastes such as pesticides, paints, used medicine and batteries. Compostable organics include fruits, vegetables and food waste. Healthcare waste contains disposable syringes, sanitary materials and blood containing textiles and is governed by the Biomedical Waste (Management and Handling) Rules 1998 and the Amended Rules, 2003, and should not be mixed with MSW .The average composition of MSW produced by Indian cities is approximately 41 wt.% organic, approximately 40 wt.% inert, with approximately 19 wt.% potentially recyclable materials. Most organic waste is generated from households, and inert waste is generated from construction, demolition and road sweeping. Waste samples collected from Delhi, Ahmadabad and Bangalore indicate that MSW composition varies between cities

Predictions on future waste growth

World waste production is expected to be approximately 27 billion tonnes per year by 2050, one-third of which will come from Asia, with major contributions from China and India . Waste generation in urban areas of India will be 0.7 kg per person per day in 2025, approximately four to six times higher than in 1999. The problems associated with waste become more acute as the size of communities increase and this provides opportunities for decentralized waste management by self-help groups and NGOs . The waste produced in urban areas of India is approximately 170 000 tonnes per day, equivalent to about 62 million tonnes per year, and this is expected to increase by 5% per year owing to increases in population and changing lifestyles . Table 5 shows that urban India generated 31.6 million tonnes of waste in 2001 and is currently generating 47.3 million tonnes. By 2041, waste generation is predicted to be 161 million tonnes, a fivefold increase in four decades

. Current waste management in India

Key waste management legislations in India

The MoEF issued MSW (Management and Handling) Rules 2000 to ensure proper waste management in India and new updated draft rules have recently been published . Municipal authorities are responsible for implementing these rules and developing infrastructure for collection, storage, segregation, transportation, processing and disposal of MSW. Chandigarh is the first city to develop SWM in a planned way and has improved waste management compared with other Indian cities

Role of the informal sector in waste materials reuse and recycling

The informal sector has a very important role in India and this must be integrated into formal SWM systems . The informal sector is characterized by small-scale, labour-intensive, largely unregulated and unregistered low-technology manufacturing or provision of materials and services Waste pickers collect household or commercial/industrial waste and many hundreds of thousands of waste pickers in India depend on waste for an income, despite the associated health and social issues. Pickers extract potential value from waste bins, trucks, streets, waterways and dumpsites. Some work in recycling plants owned by cooperatives or waste picker associations. Waste picking is

often the only source of income for families, providing a livelihood for significant numbers of urban poor and usable materials to other enterprises. Waste pickers in Pune collect organic waste for composting and biogas generation. Waste pickers also make a significant contribution by keeping cities clean.

A recent study of six Indian cities found that waste pickers recovered approximately 20% of waste, with 80 000 people involved in recycling approximately three million tonnes. It is estimated that every tonne of recyclable material collected saved the ULB approximately INR 24 500 per annum and avoided the emission of 721 kg CO2 per annum .

Waste collection and transport

Waste collection, storage and transport are essential elements of any SWM system and can be major challenges in cities. Waste collection is the responsibility of the municipal corporations in India, and bins are normally provided for biodegradable and inert waste . Mixed biodegradable and inert waste is often dumped, with open burning a common practice. Improvements to waste collection and transport infrastructure in India will create jobs, improve public health and increase tourism Local bodies spend around Rs. 500–1000 per tonne on SWM with 70% of this amount spent on collection and 20% spent on transport.

Waste disposal

SWM disposal is at a critical stage of development in India. There is a need to develop facilities to treat and dispose of increasing amounts of MSW More than 90% of waste in India is believed to be dumped in an unsatisfactory manner. It is estimated that approximately 1400 km2 was occupied by waste dumps in 1997 and this is expected to increase in the future,

Environmental and health impacts of waste dumping

Waste dumps have adverse impacts on the environment and public health . Open dumps release methane from decomposition of biodegradable waste under anaerobic conditions. Methane causes fires and explosions and is a major contributor to global warming . There are also problems associated with odour and migration of leachates to receiving waters . Odour is a serious problem, particularly during the summer when average temperatures in India can exceed 45°C . Discarded tyres at dumps collect water, allowing mosquitoes to breed, increasing the risk of diseases such as malaria, dengue and West Nile fever. Uncontrolled burning of waste at dump sites releases fine particles which are a major cause of respiratory disease and cause smog . Open burning of MSW and tyres emits 22 000 tonnes of pollutants into the atmosphere around Mumbai every year . The impacts of poor waste management on public health are well documented, with increased incidences of nose and throat infections, breathing difficulties, inflammation, bacterial infections, anaemia, reduced immunity, allergies, asthma and other infections .

Engineered landfills in India

The UN Environmental Programme defines landfill as the controlled disposal of MSW on land in such a way that contact between waste and the environment is significantly reduced, with waste disposal concentrated in a well-defined area. Engineered landfill allows the safe disposal of residual MSW on land, but protects ground and surface water from pollution and avoids air emissions, wind-blown litter, odour, fire hazards, problems with animals, birds and other pests/rodents, and

reduces greenhouse gas (GHG) emissions and slope instability issues . Properly managed engineered landfills should replace dumps in India. This would significantly reduce the environmental impact of waste .

Waste-to-energy in India

The problems associated with improper waste disposal could be significantly mitigated by requiring material recovery. Source separation of inert and high moisture content fractions would maximize the potential for thermal recovery and other treatment options in India. The waste processed in thermal recovery is residual waste that remains after all commercially viable recyclable materials have been extracted. Waste-to-energy technologies produce energy, recover materials and free land that would otherwise be used for dumping. The composition of residual waste is important for energy recovery and waste composition is changing in India, with the amount of high calorific waste generally increasing . A significant increase in the use of waste-to-energy technologies has been proposed, but this depends on location, climate, demographics and other socioeconomic factors .

The most widely used waste-to-energy technology for residual waste uses combustion to provide combined heat and power . Adopting maximum recycling with waste-to-energy in an integrated waste management system would significantly reduce dumping in India. Waste-to-energy technologies are available that can process unsegregated low-calorific value waste, and industry is keen to exploit these technologies in India. Several waste-to-energy projects using combustion of un-segregated low-calorific value waste are currently being developed. Alternative thermal treatment processes to combustion include gasification, pyrolysis, production of refuse derived fuel and gas-plasma technology.

Waste-to-energy development in India is based on a build, operate and transfer model. Increased waste-to-energy would reduce disposal to land and generate clean, reliable energy from a renewable fuel source, reducing dependence on fossil fuels and reducing GHG emissions. In addition, generation of energy from waste would have significant social and economic benefits for India. However, the track record of waste-to-energy in India highlights some of the difficulties. The vast majority of facilities have not worked effectively due to various operational and design problems. For example, the first large-scale MSW incinerator built at Timarpur, New Delhi in 1987 had a capacity to process 300 tonnes per day and cost Rs. 250 million (US$ 5.7 million). The plant failed because of poor waste segregation, seasonal variations in waste composition and properties, inappropriate technology selection and operational and maintenance issues . Despite this experience, waste-to-energy will have a key role in future waste management in India.

Barriers to improved waste management in India

The current status of SWM in India is poor because the best and most appropriate methods from waste collection to disposal are not being used. There is a lack of training in SWM and the availability of qualified waste management professionals is limited. There is also a lack of accountability in current SWM systems throughout India . Municipal authorities are responsible for managing MSW in India but have budgets that are insufficient to cover the costs associated with developing proper waste collection, storage, treatment and disposal. The lack of strategic MSW plans, waste collection/segregation and a government finance regulatory framework are major barriers to achieving effective SWM in India.

Limited environmental awareness combined with low motivation has inhibited innovation and the adoption of new technologies that could transform waste management in India. Public attitudes to waste are also a major barrier to improving SWM in India.

Changes required to improve waste management in India

Core to the vision for waste management in India is the use of wastes as resources with increased value extraction, recycling, recovery and reuse. ULBs need to be responsible for waste management, with the ULB Commissioner and Chairman directly responsible for performance of waste management systems. Waste management needs to be regarded throughout Indian society as an essential service requiring sustainable financing. The case presented to a ULB for a properly funded system must demonstrate the advantages of sound investment in waste management.

A strong and independent authority is needed to regulate waste management if SWM is to improve in India. Without clear regulation and enforcement, improvements will not happen. Strong waste regulations can drive innovation. The waste management sector needs to include attractive and profitable businesses with clear performance requirements imposed by the ULB, with financial penalties applied when waste management services are not working effectively. Finance for waste management companies and funding for infrastructure must be raised from waste producers through a waste tax. An average charge of 1 rupee per person per day would generate close to 50 000 crores annually, and this level of funding would probably be sufficient to provide effective waste management throughout India.

Information on future quantities and characterization of wastes is essential as this determines the appropriateness of different waste management and treatment options. State-level procurement of equipment and vehicles is necessary for primary and secondary collection with effective systems for monitoring collection, transport and disposal.

Littering and waste in streets is a major problem in India that has serious impacts on public health. Nagpur has introduced a system for sweeping roads in which every employee sweeps a fixed road length. The Swatchata Doot Aplya Dari (sanitary worker at your doorstep) scheme of the Centre for Development Communication was selected as an example of good practice by UN HABITAT in 2007.

Waste management must involve waste segregation at source to allow much more efficient value extraction and recycling. Separating dry (inorganic) and wet (biodegradable) waste would have significant benefits and should be the responsibility of the waste producer.

Long-term waste management planning requires visionary project development by ULBs, the private sector and NGOs. The roles and responsibilities to deliver sustainable systems need to be defined, with monitoring and evaluation to monitor progress. Experiences should be shared between different regions of India and different social groups. There are a number of research institutes, organizations, NGOs and private sector companies working on a holistic approach to SWM, and future waste management in India must involve extensive involvement of the informal sector throughout the system.

There is a need to develop training and capacity building at every level. All Indian school children should understand the importance of waste management, the effects of poor waste management on the environment and public health, and the role and responsibilities of each individual in the waste

management system. This will develop responsible citizens who regard waste as a resource opportunity.

Population growth and particularly the development of megacities is making SWM in India a major problem. The current situation is that India relies on inadequate waste infrastructure, the informal sector and waste dumping. There are major issues associated with public participation in waste management and there is generally a lack of responsibility towards waste in the community. There is a need to cultivate community awareness and change the attitude of people towards waste, as this is fundamental to developing proper and sustainable waste management systems. Sustainable and economically viable waste management must ensure maximum resource extraction from waste, combined with safe disposal of residual waste through the development of engineered landfill and waste-to-energy facilities. India faces challenges related to waste policy, waste technology selection and the availability of appropriately trained people in the waste management sector. Until these fundamental requirements are met, India will continue to suffer from poor waste management and the associated impacts on public health and the environment.

Engineering Research Institute (CSIR-NEERI) Nagpur during 25–27 March 2015 with participation of UK and Indian SWM experts.

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DEPARTMENT OF ARCHITECTURE

UNIT – III – Sustainable Waste Management – SARA5332

III. UNIT 3

Solid Waste Management in Other Countries

INTRODUCTION • To showcase the good work that is being done on solid waste by cities around the world, large and small, rich and poor. • to look at what drives change in solid waste management, how things work in cities and what seems to work better under which circumstances. • to help decision-makers, practitioners and ordinary citizens understand how a solid waste management system works; and • to inspire people everywhere, in good communication with their neighbours, constituents and leaders, to make their own decisions on the next steps in developing a solution appropriate to their own city's particular circumstances and needs. • First and foremost, it is based on the framework of integrated sustainable waste management (ISWM), especially the concepts of sustainability and inclusive good practice that have broadened and enriched the field. • This is neither a 'how-to' book nor a 'let's fix it' book, although the discerning reader will find elements of both, but more of a 'how do they do it now and what do they need to do more or less of' kind of discussion. • The book explores both expensive 'best practice' technologies, as used in highincome countries, and moderate-cost creative alternatives that improve the environment.

THE SCALE OF THE SOLID WASTE PROBLEM
• Definitions of municipal solid waste (MSW) vary between countries, so it is important to establish at the outset just what is being discussed in this book. • A working definition is 'wastes generated by households, and wastes of a similar nature generated by commercial and industrial premises, by institutions such as schools, hospitals, care homes and prisons, and from public spaces such as streets, markets, slaughter houses, public toilets, bus stops, parks, and gardens'. • Manufacturing industries generate municipal solid waste from offices and canteens, and industrial wastes from manufacturing processes. • Some industrial wastes are hazardous and this part of the waste stream requires special management, separate from other wastes. • Small workshops in urban areas generate both municipal and process wastes, some of which may be hazardous.

• Hospitals and healthcare establishments services generate municipal solid waste fractions that include food waste, newspapers and packaging, alongside specialized healthcare hazardous wastes that are often mixed with body fluids, chemicals and sharp objects. • Construction sites generate some municipal solid waste, including packaging and food and office wastes, together with C&D wastes containing materials such as concrete, bricks, wood, windows and roofing materials. • Construction and demolition wastes from household repairs and refurbishment, particularly 'do-it-yourself' wastes, are most likely to enter the municipal solid waste stream.

The working definition implies that parallel waste management systems will exist within an urban area, one for municipal solid waste run by, or on behalf of, the municipality, and others for industrial, C&D, healthcare, end-of-life vehicles and other hazardous wastes. • Definitions also change over time. Prior to rapid modernization, when a city depends on 'open access' to uncontrolled dumping, such sites normally receive all kinds of wastes, including hazardous, industrial and healthcare wastes. • While this book acknowledges the importance of good management of specific hazardous, industrial and healthcare wastes, it addresses them only by specifically excluding them from its main areas of focus. • Substantial guidance on managing hazardous wastes is available, for example, from the Basel Convention3 and the United Nations Environment Programme (UNEP), and on managing healthcare hazardous wastes from the World Health Organization (WHO).

SPECIAL WASTE STREAMS
• Healthcare waste has become a serious health hazard in many countries. Careless and indiscriminate

disposal of this waste by healthcare institutions can contribute to the spread of serious diseases such as hepatitis and AIDS (HIV) among those who handle it and also among the general public. • development of resistant strains of microorganisms; • trade in waste materials and disposed of or expired drugs that are recovered and repacked to be sold as new; • spread of disease through contact with people or animals who pick or eat waste; • increased risk of infections and sharp injuries to hospital staff, municipal waste workers and waste-pickers; • organic pollution

Solid Waste Management i n t h e W o r l d ' s C i t i e s INTRODUCTION • To showcase the good work that is being done on solid waste by cities around the world, large and small, rich and poor. • to look at what drives change in solid waste management, how things work in cities and what seems to work better under which circumstances. • to help decision-makers, practitioners and ordinary citizens understand how a solid waste management system works; and • to inspire people everywhere, in good communication with their neighbours, constituents and leaders, to make their own decisions on the next steps in developing a solution appropriate to their own city's particular circumstances and needs. • First and foremost, it is based on the framework of integrated sustainable waste management (ISWM), especially the concepts of sustainability and inclusive good practice that have broadened and enriched the field. • This is neither a 'how-to' book nor a 'let's fix it' book, although the discerning reader will find elements of both, but more of a 'how do they do it now and what do they need to do more or less of' kind of discussion. • The book explores both expensive 'best practice' technologies, as used in highincome countries, and moderate-cost creative alternatives that improve the environment. THE SCALE OF THE SOLID WASTE PROBLEM • Definitions of municipal solid waste (MSW) vary between countries, so it is important to establish at the outset just what is being discussed in this book. • A working definition is 'wastes generated by households, and wastes of a similar nature generated by commercial and industrial premises, by institutions such as schools, hospitals, care homes and prisons, and from public spaces such as streets, markets, slaughter houses, public toilets, bus stops, parks, and gardens'. • Manufacturing industries generate municipal solid waste from offices and canteens, and industrial wastes from manufacturing processes. • Some industrial wastes are hazardous and this part of the waste stream requires special management, separate from other wastes. • Small workshops in urban areas generate both municipal and process wastes, some of which may be hazardous. • Hospitals and healthcare establishments services generate municipal solid waste fractions that include food waste, newspapers and packaging, alongside specialized healthcare hazardous wastes that are often mixed with body fluids, chemicals and sharp objects. • Construction sites generate some municipal solid waste, including packaging and food and office wastes, together with C&D wastes containing materials such as concrete, bricks, wood, windows and roofing materials. • Construction and demolition wastes from household repairs and refurbishment, particularly 'do-it-yourself' wastes, are most likely to enter the municipal solid waste stream. • The working definition implies that parallel waste management systems will exist within an urban area, one for municipal solid waste run by, or on behalf of, the municipality, and others for industrial, C&D, healthcare, end-of-life vehicles and other hazardous wastes. • Definitions also change over time. Prior to rapid modernization, when a city depends on 'open access' to uncontrolled dumping, such sites normally receive all kinds of wastes, including hazardous, industrial and healthcare wastes. • While this book acknowledges the importance of good management of specific hazardous, industrial and healthcare wastes, it addresses them only by specifically excluding them from its main areas of focus. • Substantial guidance on managing hazardous wastes is available, for example, from the Basel Convention3 and the United Nations Environment Programme (UNEP), and on managing healthcare hazardous wastes from the World Health Organization (WHO). SPECIAL WASTE STREAMS • Healthcare waste has become a serious health hazard in many countries. Careless and indiscriminate disposal of this waste by healthcare institutions can contribute to the spread of serious diseases such as hepatitis and AIDS (HIV) among those who handle it and also among the general public. • development of resistant strains of microorganisms; • trade in waste

materials and disposed of or expired drugs that are recovered and repacked to be sold as new; • spread of disease through contact with people or animals who pick or eat waste; • increased risk of infections and sharp injuries to hospital staff, municipal waste workers and waste-pickers; • organic pollution THE WORLD HEALTH ORGANIZATION: THE UNITED NATIONS AGENCY FOR HEALTH AND HEALTHCARE WASTE • The WHO focuses on healthcare waste. It supports information collection and exchange, development of national policies and training. National agencies focus on implementation of national policies, guidelines on safe practices, training and promotion of effective messages. • Effective healthcare waste management will decrease infections and also benefit visitors, and will be reflected in communities through good practices in safe water, sanitation and hygiene. • In 2002, the results of a WHO assessment conducted in 22 developing countries showed that the proportion of healthcare facilities that do not use proper waste disposal ranges from 18 to 64 per cent.

LEARNING FROM HISTORY The role of development drivers in solid waste modernization11 What have been the main driving forces for development? In parallel with industrialization and urbanization, the specific drivers for the development and modernization of waste management have related to improvement of public health, protection of the environment and (first and last) the resource value of the waste ■ Driver1:Publichealth Starting in the middle of the 19th century, as cholera and other infectious diseases reached the cities of Europe and North America, legislation was gradually introduced to address the problem of poor sanitation conditions. This legislation both established strong municipal authorities and charged them with increasing responsibility for removing solid waste and keeping streets clean and litter free. ■ Driver2:Environment The focus of solid waste management remained on waste collection, getting waste out of the city, for a century – right up to the emergence of the environmental movement during the 1960s and 1970s. New laws were introduced, first, on water pollution, and from the 1970s on solid waste management, prompted by crises of contamination of water, air and land and their impacts upon the health of those living close to abandoned hazardous waste dumps. The initial response focused on phasing out uncontrolled disposal, both on land and by burning. Subsequent legislation gradually tightened environmental standards – for example, to minimize the formation of contaminated water ('leachate') and to prevent its release into groundwater and surface water from 'sanitary landfills'; and to reduce still further urban air pollution related to the incineration of solid waste in cities. ■ Driver3:Theresourcevalueofthewaste In pre-industrial times, resources were relatively scarce, so household goods were repaired andreused. Food and garden waste entered agricultural supply chain as animal feed or fertilizer. As cities grew from the 19th century with industrialization, large numbers of people found an economic niche as 'rag-pickers' or 'street buyers', collecting and using or selling materials recovered from waste; in many cases, this activity was done by peddlers who collected rags and bones from the people to whom they sold. activity continues today – virtually unchanged – in many developing and transitional country cities, where informal-sector activities in solid waste management and recycling secure the livelihood of millions of people. ■ Emergingdriver4:Climatechange14 Since the early 1990s, climate change has directed attention in the West on the need to keep biodegradable municipal waste, such as kitchen and garden wastes and paper, out of landfills in order to reduce emissions of methane (a powerful greenhouse gas). Methane forms when organic materials decompose in the absence of air, a process called anaerobic decomposition. This provides a new reason for city officials to focus on diverting biodegradable municipal waste from landfills. Partly as a result, recycling and organic diversion rates, which had declined to single figure percentages as municipal authorities focused on waste collection, began to rise in cities modernizing their waste systems, in some cases dramatically. Policy measures – including laws with targets for diver- sion from landfill, extended producer responsibility, landfill bans for recyclable waste materials, and recycling and composting goals – pushed the recovery rates up to 50 per cent and beyond, as exemplified by three of the reference cities: Adelaide, San Francisco and Tompkins County. One could argue that history has come 'full circle' now that waste management is begin-

ning to evolve into a mixed system for sustainable resource management. Box 2.1Waste management and climate change Data shows that municipal solid waste management and wastewater contribute about 3 per cent to current global anthropogenic greenhouse gas emissions, about half of which is methane from landfills. One forecast suggests that without mitigation, this could double by 2020 and quadruple by 2050. It is ironic that these forecast increases are largely due to improved disposal in low- and middle-income countries – open dumps decompose partly aerobically and therefore generate less methane than an anaerobic sanitary landfill. Mitigation needs to be a mix of the 'technical fix' approach, such as landfill gas collection and utilization, and upstream measures, particularly reduction, reuse, recycling and composting. Reduction is especially beneficial, as it also reduces the amount of 'embed- ded' carbon used to make the products that are being thrown away as waste. Modernization of solid waste management systems in developed countries For most 'developed'15 countries, the most recent wave of what is termed here as 'modernization' of solid waste management began around the 1970s, when there was a crisis of contamination from waste, either in the city, at the disposal site, or in groundwater or surface water. More important than the crisis itself, the political and media discussion around it has usually provided the immediate stimulus for change. Modernization usually begins with climbing onto the disposal-upgrading ladder – that is, with the phasing out of open dumps. Driver 2 usually results in the closing of town dumps and a plan, often not realized for many years, to develop and operate a 'state-of-the-art' regional landfill. The relatively high costs for building and operating environmental controls means that economies of scale are substantial, which favours large regional landfills, serving a number of cities and towns. Public opposition to new sites, based at least in part on bad experiences with previous uncontrolled sites (not in my backyard, or NIMBY) is a compounding factor, so that the regional landfills tend to be relatively distant from the main population centres. The geographical logistical and institutional regionalization associated with upgrading disposal sets in motion a series of rapid changes in how the waste system functions and how much it costs. The combination of higher technology, more management and longer distance to the new landfill creates a rapid upward spiral in costs for cities and their contractors: •The newly introduced landfill gate fees, based on weighing the waste, are much higher than the costs of local (largely uncontrolled) disposal. •Collection and transport costs are much higher, as the longer distances imply increased time on the road and increased fuel consumption, and possibly the need for local transfer stations. •There are also increased (and often unbudgeted) administration costs involved in organizing 3, 15 or even 50 separate cities and towns together to agree on where the landfill should be, which community should host it, and how the laws, regulations and administration should work. •Political NIMBY opposition to siting intro- duces legal battles that cost the local authority time and money to answer challenges in courtand in the political arena. It is in part to illustrate this process that the reference 'cities' actually include two multi-municipality regions: Adelaide, Australia, is a regional municipality with 19 cities or towns; and Tompkins County, in New York state, is a typical North American unit of government that combines one city, Ithaca, with ten other towns in a relatively rural area. In many developed countries, this upward spiral of costs triggered a search for less expen-sive ways to be modern and environmentally responsible. Some part of the strong interest in recycling and composting came about because, when compared to regional disposal, these activities began to appear to be less expensive, as well as environmentally preferable. During the period of active modernization in the US, for example, recycling goals in many states increased from 15 per cent of total waste to more than 50 per cent in a relatively short period of time at the end of the 1980s Modern municipal recycling, as it has been reintroduced in Europe and North America since the 1970s, depends on households segregating materials at the source. This means that waste system users, the households, need to change their habitual behaviour and to separate their waste into several categories, which they store separately, rather than mixing it all together in one basket, bag or bin. Collecting several source- separated waste streams without greatly increasing collection costs is a similar challenge to the waste collection providers and operators: they also have to change the way in which they think and behave. This has

led, in some instances, to a reduction in collection frequency for the residual waste The solid waste challenge in developing and transitional country cities Experience in low and middle income countries can also be related to the same drivers. The plague epidemic in Surat is one example of a public health crisis that stimulated new initiatives to collect the waste and clean up the city, now known as one of the cleanest in India. The landslide at the Payatas dumpsite in Quezon City, the Philippines in July 2000 killed 200 people – a terrible tragedy – but it also catalysed the political process that resulted in the passage of Republic Act 9003, the Ecological Waste Management Act, one of the most complete and progressive solid waste management laws in Asia. Reawakening interest in resource management has inspired a public– private partnership in Dhaka, Bangladesh, that was one of the first to be issued climate credits. Solid waste management is a major challenge for many cities in developing and transitional countries. The urban areas of Asia were estimated to spend about US$25 billion on solid waste management each year in 1998. Solid waste management represents 3 to 15 per cent of the city budget in our reference cities, with 80 to 90 per cent of that spent on waste collection before modernization. Collection coverage in the reference cities, as in urban areas in general, varies widely, ranging from 25 to 75 per cent in cities where the norm for waste disposal is still open dumping. Why should the authorities choose to invest in a waste system when such investment is likely to raise costs and offer competition for scarce financial resources to other critical municipal systems, such as schools and hospitals? Box 2.2 Plague-like epidemic in Surat, India19 Uncollected solid waste blocking drains caused a major flood, leading to an outbreak of a plaguelike disease in Surat, India, in 1994.The disease caused panic countrywide, and while the citizens blamed the municipality, the public authorities, in turn, blamed the citizens for their lack of civic sense. Over 1000 plague-suspected patients were reported, with the final death toll of 56 people.The city incurred a daily loss of 516 million Indian rupees during the plague period and a total loss amounting to 12 billion rupees.This was a high price to pay for negligence in the area of solid waste management. Alarmed at the situation, the Surat Municipal Corporation undertook a stringent programme of cleaning the city.Within a year after the plague, the level of (daily) solid waste collection increased from 30 to 93 per cent, and 95 per cent of streets are cleaned daily. Market areas, major roads and litter-prone spots are cleaned twice a day. Surat is now identified as one of the cleanest cities in the region. https://thecitywasteproject.files.wordpress.com/2013/03/solid_ waste_management_in_the_worlds-cities.pdf Source:

Solid waste and the Millennium Development Goals (MDGs) • The Millennium Development Goals (MDGs) were ratified by 189 heads of state at the United Nations Millennium Summit in September 2000,with the overall objective of halving world poverty by 2015. • MDGs 1 and 7, on livelihoods and poverty, on the one hand, and on environment, on the other, point to the urgency of inclusive policies in waste management so that the role of the informal waste sector in cleaning up cities and recovering resources is recognized, while working conditions and livelihoods are improved. • Improving the coverage of waste collection services contributes to the healthrelated MDGs 4, 5 and 6, and will reduce both child diseases and mortality. • MDG 8, on global partnerships, is a blue-print for cities to work with private formal and informal actors, on the one hand, and to join with communities in participatory planning and problem solving, on the other. • Partnerships can improve governance, bring about financial sustainability and support proactive policy formulation. Solid waste and the Millennium Development Goals (MDGs) The integrated sustainable waste management (ISWM) framework • When the current modernization process started in developed countries during the 1970s, solid waste management was seen largely as a technical problem with engineering solutions. That changed during the 1980s and 1990s when it became clear that municipalities could not successfully collect and remove waste without active cooperation from the service users. • ISWM identifies three important dimensions that all need to be addressed when developing or changing a solid waste management system – namely, the stake- holders, the elements

and the sustainability aspects. • The examples from Denmark or Japan –which some would regard as world icons of good waste management practice – suggest that a sustainable, affordable waste management system consists of a stable mixture of technologies and institutions, which function flexibly under a clear policy umbrella. • In low and middle-income countries, there is often a variety of formal and informal, public and private systems already operating, so the basis for a stable mixed system is already in place. What most low- and middle-income cities miss is organization – specifically, a clear and functioning institutional framework, a sustainable financial system, and a clear process for pushing the modernization agenda and improving the system's performance The integrated sustainable waste management (ISWM) framework The integrated sustainable waste management (ISWM) framework • The stakeholders – the people or organizations with a 'stake' or interest in solid waste management: who needs to be involved? • The elements – the technical components of a waste management system: what needs to be done? • The aspects which need to be considered as part of a sustainable solution: how to achieve the desired results? • 'Integrated' in ISWM refers to the linkages and interdependency between the various activities (elements), stake-holders and 'points of view' (sustainability aspects). Moreover, it suggests that technical, but also legal, institutional and economiclinkages are necessary to enable the overall system to function Sustainability in solid waste management is possible • 'too good to be true', I • If there was one thing to learn from the Naples, Italy, waste strike in 2007 to 2008, it is that no matter what the politicians do, the solid waste keeps coming. And the public who generate it and the politicians and officials responsible for managing it need to understand what they are doing and be able to make good decisions based on sound local knowledge is probably not true. • For example, large waste-compaction collection vehicles designed to collect lowdensity, high-volume wastes on broad suburban streets built to withstand high axle-loading rates in Europe or North America are unlikely to be suitable for use in a developing country city. There the vehicles have to be smaller, lighter and narrower to allow collecting much denser wastes from narrow streets and transporting it over rutted roads going up and down steep hills – even wellsurfaced main roads tend to be designed for lower axle-loading rates. In many cases, a small truck, a tractor or even a donkey fits local collection needs, while a 20 tonne compactor truck does not. Sustainability in solid waste management is possible • It is this need to keep going, day in and day out, that makes it so critical to shift from the term 'solid waste management' to 'sustainable waste management'. • 'Sustainability' is a long word for 'common sense', and there are some relatively simple ways to improve the performance and sustainability of waste management systems. • ISWM is that all stakeholders need to be engaged and all sustainability aspects need to be addressed. It is the transparent processes of users talking to providers, communities sharing responsibility for planning, and recycling businesses working with cities that make for sustainability. Dare to innovate • At most, low- and middle-income countries have, until now, sought to adapt the models from developed countries to their local circumstances. • Daring to innovate, or to 'think outside the box', helps us to understand, for example, how solid waste is different from many other public utility functions, as the following example shows. • The closest public service to solid waste, in terms of its regularity and complexity, is perhaps the postal service. In a sense, waste management could be viewed as a kind of 'postal system in reverse' – indeed, some researchers have classified waste management as 'reverse logistics'. RECYCLERS AND CLIMATE CHANGE • Material recovery and recycling are for us the best options for managing urban waste. The industrialized countries must reduce their consumption of natural resources, limit the generation of waste, increase recycling and avoid all exports of waste and technologies contributing to climate change. • Recognize the critical and productive role that the recyclers contribute to the mitigation of climate change, and invest resources in programmes for recovery at source that ensure a dignified way of life for all workers and traders from the recycling industry. • Study and remove the support for all projects that divert recyclable waste to incineration or landfilling. • Establish mitigation mechanisms that are directly accessible by recyclers and which are significant in terms of financial and technical support. • Consult the recyclers first in relation to energy from waste generation. •

Support projects and technologies that divert organic waste from landfills by means of composting and methane production, and which should be adopted as options due to the reduction of methane. CONCLUSION • Most people don't care where their waste goes, as long as it is not next to their house. • Whereas an individual misses their post, the individual opting out of a waste management service doesn't notice much 'personal' impact. It is much easier, as well as much more harmful, to burn or dump your own waste than it is to generate your own electricity, or, indeed, to deliver your own letter to your family in a distant village • Waste management isn't as technically complex as energy or housing, but it does have its own set of issues and solutions, and these deserve attention. • So are effective systems to address the 3Rs: reduce, reuse, recycle (i.e. to reduce the quantities of waste generated, and to build on the existing, largely informal sector systems for reuse and recycling.

INTRODUCTION: Because of the difficulties in obtaining comparable information from cities, this Global Report is based on profiling and presenting 20 reference cities. This chapter introduces both the cities and the methodology that has been created to stimulate their participation, and to increase the comparability and accuracy of the data that has been collected. Presenting information in a consistent way helps to understand how things work within and across countries. Solid waste management is fragmented across cities and countries, as well as within them. For this reason, this Global Report profiles a group of reference cities in a consistent way, asking research questions about the nature and sustainability of waste management and recycling in a globalizing world. REFERENCE:SOLID WASTE MANAGEMENT IN THE WORLD'S CITIES-WATER AND SANITATION 2010 PROFILING THE REFERENCE CITIES Global Report 20 reference cities increase the Comparability and accuracy of the data that has been collected. Presenting information in a consistent way helps to understand how things work within and across countries For this reason, this Global Report profiles a group of reference cities in a consistent way WHY: Example: European countries research question: about the nature and sustainability of waste management and recycling in a globalizing world. SELECTING THE REFERENCE CITIES The goal for working with 20 cities was a need for: • a qualitative understanding of what drives the system, how it works and who is involved in it; • hard data and facts from official and reported sources, framed and validated by the visual presentation of a process flow; • information on what works and what doesn't, both in individual cities and across cities. Two sets of criteria were used: Criteria for the mix of cities: • a range of sizes, from mega-city to small regional city; • a range of geographic, climatic, economic and political conditions; • the distribution of cities to include most in low- and middle-income countries, with a significant number in Africa; Criteria for each city: • a city that is willing to participate; • a city willing to invest in preparing the materials and providing information; • a city willing to share both good and not-so-good practices; • someone from or working closely with the city who is willing to take responsibility for collecting data from that city and preparing it in the form desired; • the more close the contacts with the city, the more favourable it is to include it. REFERENCE:SOLID WASTE MANAGEMENT IN THE WORLD'S CITIES-WATER AND SANITATION 2010 The goal for working with 20 cities was a need for: • a qualitative understanding of what drives the system, how it works and who is involved in it; • hard data and facts from official and reported sources, framed and validated by the visual presentation of a process flow; • information on what works and what doesn't, both in individual cities and across cities. SELECTING THE REFERENCE CITIES Two sets of criteria were used: Criteria for the mix of cities: • a range of sizes, from mega-city to small regional city; • a range of geographic, climatic, economic and political conditions; • the distribution of cities to include most in low- and middle-income countries, with a significant number in Africa; at least one from each continent, including a few from high-income countries. CRITERIAS USED: 2 Criteria for each city: • a good illustration of one or more of the main topics and main messages around which the Global Report is structured; • a city that is willing to participate; • a city willing to invest in preparing the materials and providing information; • a city willing to share both good and not-so-good practices; • someone from or working closely with the city who is willing to take

responsibility for collecting data from that city and preparing it in the form desired; • the more close the contacts with the city, the more The 20 reference cities used in the book provide a reasonable cross-section across the world, but meeting all possible selection criteria is challenging. It is hoped that similar city profiles will be prepared and published in the future; priorities for inclusion would include cities from the former Soviet Union/Newly Independent States; Middle East; English-speaking West Africa; Portuguese-speaking Africa and an island city state.

How is it possible to research and understand 20 cities in a short period of time? Some basic instruments have been derived from the integrated sustainable waste management (ISWM) framework, with a focus on three system elements and three governance aspects, and include: 1. using a process flow approach to understanding the entire waste and recycling system through the construction of a process flow diagram (PFD); 2. developing and requesting unusual data points and indicators as a way of extending the boundaries of what can be understood and compared; 3. designating a person who has worked in the city and knows it well, named hereafter the 'city profiler' 1. process flow diagram (PFD) gives a fast picture of what is happening to which streams; • the whole system is included in the analysis; • where the system boundaries are and provides a structure for analysing the materials that 'escape' from the system; • shows where the materials actually end up; • provides a check on data provided in other ways • allows for and, indeed, facilitates understanding linkages between formal and informal activities, actors and steps in the chain of removal, processing, valorization or disposal; • the degree of private-sector participation in the system and in the management of different materials; • is a reliable way of estimating recovery rates for specific materials and mixed streams; • allows for comparison of costs and efficiencies between different operations and for the system as a whole; • shows the degree of parallelism and mixing in the system. Information and indicators A short set of indicators was, secondly, prepared based on the six ''themes' of ' good practice in ISWM components that form the focus of this report, as follows. Three drivers and physical elements: 1 Public health/collection. 2 Environment/disposal. 3 Resource management. Three ISWM governance aspects, which include: 1 Inclusivity. 2 Financial sustainability. 3 Sound institutions and proactive policies. These indicators are useful for analyzing how processes work within a city and comparing across cities. The point is not so much to see how one city 'scores', but how things cluster and what this tells about the city. One of these new indicators was inspired by the experience of Delhi/New Delhi, where the profiler and Chintan-Environmental, the host NGO, were astounded to find out how challenging it was for the city officials to find or provide information. This led to the creation of a relatively new governance indicator: the age of the most recent reports that are available. In the comparative tables distributed throughout this Global Report, as many cities as possible will be included in the comparison based on the availability of information per city. In cases where information is not reported, the abbreviation NR will be marked, and in cases where information is not available, the abbreviation NA is used. The role of city profilers Third, the individuals who described the cities for the book (the 'city profilers') are mentioned; these city profilers collected examples, stories, photos, newspaper articles and other qualitative information. Together with the profilers, the co authors and editors of the book used their collective experience to really understand the 'story' of solid waste in each city, how the drivers have influenced solid waste, and how to understand both successes and problems. Some examples of 'stories' include the following: • Cities with good collection at the submunicipal level, such as Bamako or Nairobi or Managua, may have distant, limited or no controlled disposal simply because there is no one at the city council level who 'owns' the problem or is committed to proactively seeking a solution. • Or consider the paradox of Curepipe, Adelaide and Rotterdam: too much moderately priced disposal reduces incentives for both users and providers to work on source separation and recovery of recyclables and organic waste – even when there is a policy commitment. The result is missed opportunities and disappointing recycling performance. Other ways of understanding the cities include comparative tables, photos, diagrams and stories; these have come from the city profilers;

from their sources (both in terms of reports and in terms of talking to people) in the cities; and from the collective professional memory of all the writers and teams working on the Global Report. The sum of all these parts is designed to give a three-dimensional insight into the cities that builds understanding about ISWM in specific places, and also in its totality

INFORMATION QUALITY If knowledge is power, than a city without knowledge of its solid waste system may lack the power to make positive changes. Solid waste information is subject to a number of widely encountered structural weaknesses. In many cities, information on solid waste is: • old – more than 10 years' old and, in some cases, more than 15, while changes in the composition of the waste stream, population and behaviour are continuously occurring; • orphaned – neither owned nor recognized by the city itself, particularly in low- and middle-income countries, where a donor, or a state, provincial or national government paid for the study or financed the consultant, and did not ensure that the information was useful for the city; or where there is no central archiving system in the city; • secret – considered to be secret or proprietary because of the involvement of private-sector actors or investors; • estimated – estimated based on national or regional figures, without verification in field assessments; • political – highly politicized and subject to distortions in support of the policy ambitions of particular stakeholders; • not permanent – because it related only to a specific period of a government administration and experiences from previous administration are seen as 'useless'; • missing – missing or incomplete because there is no party willing to invest in gathering accurate information on such a dirty subject; and/or • inaccessible – because it might not be written in the language of the municipality, but rather in the language of the consultant hired by the donor. On the other hand, city governments or solid waste agencies that consider waste to be a priority have the tendency to invest in monitoring and documentation of waste information and reap the benefit of good data. And cities that have a strong resource management driver and are seeking to achieve high recovery rates are often willing to invest more in detailed waste characterization studies, so that they really understand what can be recovered. As a result, quality of information may serve as an indicator of commitment. CITY INDICATORS • Each city has a series of indicators that are representative of different aspects of a city's solid waste system. Behind these indicators are the overarching 'drivers' for the modernization of the solid waste management system, which include improving public health, reducing impacts to the environment, and increasing resource recovery through minimizing waste generation combined with increasing materials recycling. These three drivers should be considered linked; addressing impacts upon the environment necessarily includes addressing potential impacts upon human health. Similarly, reducing waste generation and subsequent disposal through waste prevention, reuse and recycling has quantifiable benefits to both human health and the environment. • An integrated and sustainable waste management approach to solid waste necessitates addressing these three elements; but this is done within the context of government institutions. The modernization of the solid waste management system often sees establishment of new policies, regulations and possible restructuring of management and administration to better address the minimization of public health and environmental impacts while maximizing the recovery of resources from the waste stream. • An 'indicator' suggests that a data set has been chosen to provide an indication of how a city has addressed one of the aforementioned drivers. The chosen indicators in Table 3.2 should not be considered as the only lens through which one would assess the movement towards a modernized solid waste management system. Description of each indicator • Collection/sweeping coverage: percentage of the city that receives a regular service of waste collection and street sweeping. The driver is public health, involved with keeping garbage and the associated vectors from waste accumulating within the city. • Controlled disposal:percentage of the waste that ends up in a disposal facility with basic controls.The driver could be considered both public health, especially with labor associated with disposal sites, as well as environmental protection of soil, water and air resources.

SAN FRANCISCO California, West Coast, US, North America • The city and county of San Francisco, California, is the financial and administrative capital of the western US and a popular international centre for tourism, shipping, commerce and manufacturing. • The initiator of the United Nations Environment Programme (UNEP) Urban Environmental Accords, San Francisco, is a national and international environmental leader. • This willingness to take the lead is what drives San Francisco's environmental programme. Collection of waste in San Francisco • The Fantastic 3 Program, initiated in 1999 and completed citywide in 2003, uses black, blue and green 240-litre wheeled carts. • Generators segregate materials and split chamber trucks simultaneously pick up trash and recyclables. • streets are swept mechanically at least once per week; several high-traffic areas are swept daily. disposal • Since it does not have a landfill, San Francisco's discards are hauled 85km to Waste Management's Altamont Landfill. • Garbage rates have been set to strongly encourage recycling or composting. • In the commercial sector they are discounted by up to 75 per cent off the cost of trash. • In the residential sector, recycling and composting collection are provided at no additional cost. • This 'pay-as-you-throw' system underpins San Francisco's diversion strategy and drives environmental programmes. Resource management • The average San Franciscan generates 1.7kg of waste per day, of which 72 per cent is recycled. • Three-quarters, 75 per cent, of the remainder could be diverted by existing programmes, and once this is realized, the city will achieve more than 90 per cent diversion. Special features • 'Zero waste or darn close'. The zero waste challenge is reflected in solid waste system support for reducing consumption, maximizing diversion and encouraging reuse, repair and green purchasing. • banning troublesome goods such as plastic bags and superfluous packaging, and promoting alternatives such as recyclable or compostable take-out food packaging and reusable transport packaging. • Most of these actions require ongoing outreach at homes, schools, businesses and events. • In some cases, mandates and ordinances are required, such as mandatory segregation of recyclables and organics, and construction and demolition debris. • One next major step includes supporting the passage of state wide legislation that holds manufacturers, businesses and individuals accountable for the environmental impact of the products that they produce and use. ROTTERDAM South Holland, The Netherlands, Europe • The main driver has been the growing environmental awareness among the population and the increasing tendency to preserve the resource values of waste. • This awareness has resulted in an aggressive Dutch national policy framework that works to eliminate landfilling and maximize materials and energy recovery. • Rotterdam's compliance is selective: the city chooses to maximize energy recovery. Collection • ROTEB, the municipal waste management department, is run as a public company although its budget comes from the municipality. • Waste collection operates according to a weekly routine, applying one (plastic bag, 240 litre container), two (plastic bag, 1100 litre container) or three (3m3, 4m3 and 5m3 underground containers) collection services per week. Disposal • The high water table in The Netherlands and its high degree of urbanization have pushed the country to opt for minimizing landfilling and optimizing recycling, composting and incineration. Disposal: • The result is a dense network of processing and disposal facilities owned by both private and public companies, and Rotterdam has more than its share of high-performance disposal facilities. Resource management • During the 1980s The Netherlands was one of the most progressive and recycling-oriented countries in Europe, together with Germany and Denmark. • The recovery strategy is based on research and analysis of the environmental footprint of 29 classes of products and materials. • National policy goals regarding recycling and waste minimization are established in the recently updated National Waste Management Plan 2009– 2021.

WASTE COLLECTION: PROTECTING PUBLIC HEALTH Basic issues Together with sanitation as the safe management of human excreta, effective removal and treatment of solid waste is one of the most vital urban environmental services. Waste collection represents both an essential utility function, together with electricity, gas and clean water, and a necessary part of urban infrastructure and services, alongside housing and transport, education and healthcare. In cities, poor solid waste management has a direct impact upon health, length of life and the urban environment. This matters

and it is the basis for the idea that removing solid waste from urban centres is an essential function of the city authorities. Ever since the middle of the 19th century, when infectious diseases were linked for the first time to poor sanitation and uncollected solid waste, municipalities have therefore been responsible for providing solid waste collection services to their citizens. When solid waste is not removed, it ends up somewhere. That 'somewhere' is open spaces, backyards, public parks, alongside roads or pathways, and in nearby rivers or lakes. Waste is burned in a barrel or in a heap. Children, especially those living in slums, play in it and with it. Poor waste management usually affects poor people more than their richer neighbours. Often the city centre receives a door-to-door collection several times per week and the periurban or slum areas rely on containers that are emptied so seldom that the area around them becomes an informal dumpsite, attracting insects, rats, dogs and grazing animals, and, always, more waste. Maharashtra in India banned the manufacture, sale and use of plastic bags in 2005; unfortunately, poor enforcement means that the ban has so far been ineffective. In West Africa, floods are being blamed on the small plastic pouches for drinking water. Uncollected waste has economic, social and technical costs for a city. A dirty and unhealthy city will make it difficult to attract businesses. In Tangier, Morocco, pollution of beaches by solid wastes was cited during the late 1990s as the leading cause of tourism decline that cost hotels in the area US$23 million per year in lost revenues.4 In Costa Rica, the electric utility company has had so many problems with plastic litter clogging the turbines of their hydroelectric plants that they are financing plastics recycling in the catchment area behind their dams. Insights from the reference cities and global good practice in waste collection Effective waste collection is all about the city authorities understanding their citizens and their city, and making a focused and sustained effort to mobilize the human and financial resources. Many parts of the system need to work together to remove waste, serve households and keep the city clean. The authors of this Third Global Report generally agree with their colleagues worldwide that getting collection under control is the first step in climbing onto the modernization ladder. The reference cities show a wide variety of experience and give some new insights into how to do this efficiently, fairly and effectively. This section explores this under three headings, which echo the experiences of the cities and what they are proud of doing well: • keeping the cities clean; • improving cost effectiveness of the services; • creating effective channels of communication between users and providers. The wastes are collected by single-axle (4 2) compactor trucks that average 8000kg per load, with a gross vehicle weight of 17,000kg (although this exceeds the legal gross load limit of 15,000kg for 4 2 trucks in the country concerned) and are transported directly to the landfill. This is a very slow system as the trucks must travel long distances (average 6km 2 = 12km return journey) within the city as well as long distances (40km 2 = 80km return journey) to the landfill. Collection must take place at times when the city is free of traffic, taking 2.5 hours

INVESTMENT IN DEVELOPING COUNTRIES: • Achieving financial sustainability is still a work in progress in all of the developing country cities. Financing and investment needs are serious in waste management, especially for middle- and small-sized cities and in low-income countries. • The investment needs are estimated based on 'internationally recognizable' standards and environmental protection solutions are not affordable for the governments and their people. • As a result present strategies, action plans and investment projects of developing cities cannot afford or sometimes, even when it does, the result is a landfill site that waits for the landfill to be built, or an investment in a processing facility that the city cannot afford to operate. • The organizations which could provide the necessary finances are generally just not available. • Solid waste budgets largely come from national governments, but they do not have the funds to invest in new infrastructure. This leaves the international financial institutions and private investors, who bring a range of conditions where most of if require 'international' standards on which they are not allowed to compromise or affordable for the recipient. ISSUES FACED WHILE RUNNING MODERN LANDFILLS: • The research in this Global Report confirms that the operational cost for primary collection is generally affordable, even

in poor communities; secondary collection already raises issues of affordability and willingness to pay in many cities. • Modern landfills to donor standards is often beyond the capacity of municipal governments: the Ghorahi site is an exception which is funded by local sources that makes use of a natural clay 'liner', which may or may not be acceptable to some donors • If the donor capital is a grant, two issues arise, 1. ISSUE 1 - The first is the capacity of the city to operate and maintain the equipment or facility as it was designed, whether a collection vehicle, a landfill site or a treatment plant – the world is littered with examples of donated compactor trucks or incinerators which don't work, and landfill sites which have reverted to open dumps because the city cannot afford to run them or to repair them. 2. ISSUE 2 - How to replace the vehicle or the landfill site at the end of its life. Grant funding may be helpful in the right circumstances and if the vehicle or facility is appropriate, which is not a long-term solution. • If the investment is a loan, then the issue is not just about operational cost but also about debt repayment. A city can only afford to borrow a certain amount if it is to meet the repayments, so solid waste must compete with other funding priorities, such as health and education. • But individual cities and countries cannot solve this on their own a sustainable local solution must be acceptable, appropriate and affordable in the local circumstances. • However, neither International Financial Institutions, nor National Governance Structures are geared to this 'pickand-mix' approach. IFIs and their governing boards need to look again at their policies, particularly at their insistence on 'international standards' as a condition for financing. • It has taken 40 years of the current phase of solid waste modernization for developed countries to achieve these standards across the board, so it seems unreasonable to insist that the same standards form part of the next step in every developing country as a condition of providing financial assistance. MAKING INTEGRATED SUSTAINABLE WASTE MANAGEMENT SUSTAINABLE… • Identifying and naming problems, meetings with a range of stakeholders, finding solutions that are appropriate to specific local situation in order to set off from where you are and where you want to be. • If in a early stage of this journey of modernization of solid waste management system, then it is important to identify simple, appropriate and affordable solutions that can be implemented progressively which can be afforded. • ISWM approach is to focus on building your existing recycling rates and taking measures to bring waste growth under control. This is particularly important, as every tonne of waste reduced, reused or recycled is a tonne of waste for which the city does not have to pay for its transport and safe disposal. • The best strategy is to understand and build upon the strengths of the city – to identify, capitalize on, nurture and improve the indigenous processes that are already working well.

PUTTING INTEGRATED SUSTAINABLE WASTE MANAGEMENT INTO PRACTICE υ All the key principles of solid waste management are listed above. υ ISWM – Case studies on Delhi, Banglore, Ghohari. υ It involves both the users and service Providers. Building Recycling Rates: υ Solid Waste modernization happened – 1990's & 2000's. υ Every countries started to set recycling goals to achieve to work on high recycling rates to divert the waste from landfills to reduce the cost. υ In many countries, recycling had fallen & they had gone to new systems like, Landfill taxes, recycling targets, extended producer responsibility. υ It makes less cost. υ Comparision of recycling rates with modern western systems. υ They had mentioned the % of recycling rates with the numeric data. υ The waste from the streets & dumps along the built-up area should be recycled or else the rate of recycling would be dramatically increased. υ Even in Delhi had contributed to 16% of recycling rate. A focus on waste reduction: υ Before waste recycling , at first we have to redue the waste being produced - 3R. υ Zero waste in South Australia provide a good global practice on 3 R concepts. υ In US & Rotterdam, reuse & the organization of recycling process is very important process. υ The kitchen wastes are recycled as livestock feeding . υ Even in Srilanka and Bulgeria, a formal recycling Programs happened. υ Cencus shows that for past 40 years, good policies of solid waste management increased. υ Waste quantities increased due to the population. An ISWM approach is likely to come at the problem from three directions at the same time: υ 1. from the 'bottom', to get onto the hierarchy

in the first place by phasing out open dumps; υ 2. from the ‘middle’, ensuring that wastes are increasingly diverted from disposal to reuse, recycling, organics valorization and composting; and υ 3. from the ‘top’, to reduce waste at source and to bring waste growth under control so that a city can make real progress rather than ‘running hard simply to stand still’. Use all available sources of finance: υ CDM (Clean Development Mechanism) to improve Waste management. υ At early 1990’s, Landfills sites are developed by the donor giving only capital cost but it was failed due to the lack of operational cost. υ A amount is given annually to a city for the mainatenence of landfills to collect the gas out of waste which can be used as electricity. υ Dhaka – obtain the carbon credits for recycling. υ Extended Producer Responsibility (EPR) . υ In Europe, has been successful because they had managed the retailers and producers for waste seperations. υ The best example is Netherlands – Middle income country. υ The other innovative Examples- Youth NGO with Zabbleen community of Informal Waste collections. Conclusions : υ The approach is creative & critical. υ Built up the cities in our own way. υ To all involve all the stakeholders. υ Adapt the solutions that will work in our particular situation.

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT – IV – Sustainable Waste Management – SARA5332

IV. UNIT 4

Waste as a Resource

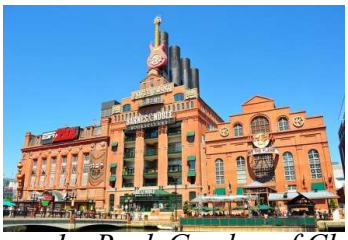
Architectural reuse – waste prevention, pre building, building, post building stages, construction and demolition recycling -Conservation of natural and building resources – types of wastes – elimination of waste and minimize of pollution – various decomposing methods - Environmental monitoring and testing during construction – design facility within social and environmental thresholds

Adaptive reuse

- refers to the process of reusing an old site or building for a purpose other than which it was built or designed for.

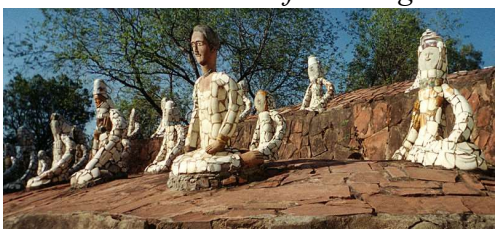
Factors affecting adaptive reuse

- **societal value** of a given site
- **potential** for the reuse of a particular site;
- **historical** importance of the site - terms of both the physicality of the street-scape and the area
- **natural** ecological conditions of the site



Pratt Street Power Plant in Baltimore, Maryland, United States, converted into retail, restaurants, and offices.

Figure 1 - Rock Garden of Chandigarh



it is spread over an area of forty-acres,
it is completely built of industrial & home waste and thrown-away items.
man-made interlinked waterfalls and many other sculptures that have been made of scrap & other kinds of wastes (bottles, glasses, bangles, tiles, ceramic pots, sinks, electrical waste, etc.) which are placed in walledpaths), complex of interlinked courtyards, each filled with hundreds of pottery-covered concrete sculptures of dancers, musicians, and animals

"Waste - a resource in the wrong place"
-- An old Chinese proverb

Waste – Noun Vs Verb

waste *v.*	**waste** *n.*
1. to **use**, consume, spend, or expend thoughtlessly or carelessly	1. a place, region, or land that is **uninhabited or uncultivated**
2. to **cause** to lose energy, strength, or vigor; exhaust, tire, or enfeeble	2. a **devasted or destroyed** region, town, or building; a ruin
3. to **fail** to take advantage of or use for profit	3. a **useless or worthless** by-product, as from a manufacturing process
4. **to destroy** completely	4. garbage; trash

Waste prevention ……right form	
Planning Process	Site selection and planning Budget planning Capital planning Programme planning
Design Process	Client awareness and goal setting - Green vision, project goals & green design criteria Team development Well-integrated design Resource management Performance goals
Operation & Maintenance	Commissioning of building systems Building operation Maintenance practices Renovation & demolition

Table 1 – Waste classification

Construction Waste Management

- Responsible management of waste is an essential aspect of sustainable building.
- sustainable management of resources - **reduction, recycling, and reuse** of wastes
- In this context, managing waste means
  - eliminating waste where possible;
  - minimizing waste where feasible; and

– reusing materials which might otherwise become waste.

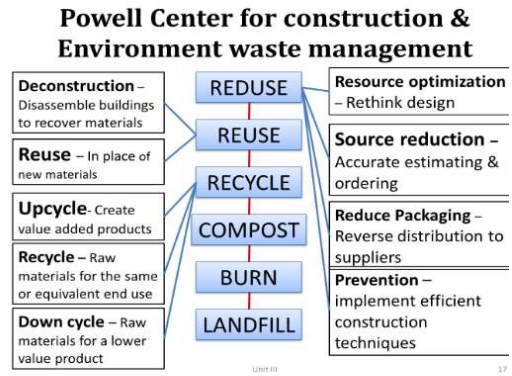
Effective management of building-related waste

- Waste prevention
- Recycling construction and demolition materials
- Architectural reuse (include adaptive reuse, conservative disassembly, and reusing salvaged materials)
- Design for material recovery (durability, disassembly, adaptive reuse)

Figure 2 – Measures

Waste prevention is about the way in which the **products and services** we all rely on are

- designed
- Made
- bought
- sold
- Used
- Consumed
- disposed



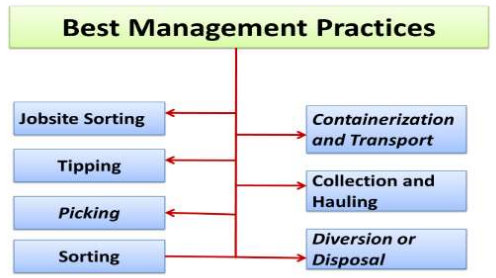


Figure 3- Management Practices

Jobsite Sorting	• efficient identification and sorting of materials is an important factor • Materials may be sorted into a number of containers provided by service companies that specialize in management of specific types of waste at the jobsite. • least number of containers is desirable both to keep container volumes high to reduce transportation trips and costs
Collection and Hauling	Containers containing construction and demolition waste are collected and transported to diversion facilities via truck.
Tipping	Identification of loads on arrival at construction and demolition debris diversion facilities is an important step in ensuring materials are appropriately handled.
Picking	Materials such as steel reinforcing bar, carpeting, large pieces of wood, concrete and materials with dimensions greater than 3 feet are usually picked before the sorting process can begin in earnest.
Sorting	involves loading materials onto an inclined metal belt—a chainbelt—and passed across a manual sortline consisting of a flexible rubber belt and integral sort stations providing a place for several workers to stand, usually opposite from one another down the length of the belt. Materials are identified, grabbed, and deposited in vertical openings at each sort station.
Containerization and Transport	Picked and sorted materials are deposited by means of equipment and manual labor into industrial containers of various types. Heavy interstate trucks are an important part of the transportation system. Containers of all types are destined for transport locally, regionally, nationally and internationally.
Diversion or Disposal	incorporation in new products as recycled material, or are processed for reuse. Materials destined for disposal in landfills include refuse, materials contaminated with waste or which have been ruined, and materials for which markets do not exist.

Table 2 – Classification

Figure 1 - A simplistic perspective on the building supply chain

Construction & demolition recycling

- Building materials account for about **half of all materials used** and about **half the solid waste generated** worldwide.
- They have an environmental impact at every step of the building process—
  - extraction of raw materials
  - processing
  - manufacturing
  - transportation
  - construction
  - disposal at the end of a building's useful life.

construction and demolition waste

- Construction and demolition (C&D) waste is a general term for a diverse range of materials that, when segregated, can include high-value materials and resources for new construction.
- Construction and demolition waste is generated whenever any construction/demolition activity takes place, such as, building roads, bridges, fly over, subway etc.
- consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics **etc.**

Advantages and Disadvantages of Source Separation vs Commingled Recycling		
Recycling Method	**Advantages**	**Disadvantages**
Source Separation - separating different recyclable materials at the job site	• Higher recycling rates • Lower recycling costs; revenues paid for some materials • Often a cleaner, safer work site	• Multiple containers on site • Workers must separate materials for recycling • More complex logistics • Multiple markets; more

		information to manage
Commingled Recycling-means placing all recyclable materials into a single container, which is then transported to a processing facility, where different materials are separated by hand or by automated equipment.	Only one or two containers on site • No need for workers to separate materials for recycling • Easier logistics • One market; less information to manage	• Lower recycling rates • Higher recycling costs

Table 3 - Advantages and Disadvantages of Source Separation vs Commingled Recycling

Source separation

- is more complex because workers must separate waste materials before they throw them away
- there are more containers on site
- there are more markets and haulers to work with and keep track of.

source separation is economically more advantageous than commingled recycling

- Source separation produces materials that are ready to go directly to market;
- there is no need to pay a processor to sort materials.
- Source separated materials are generally of higher quality, with fewer contaminants
  - They're worth more in recycling markets

A few additional rules make source separation work smoothly

- Keep as few containers as possible on site at any time.
- Match containers to the material.
- Place containers close to work locations

WHAT TO LOOK FOR IN A HAULER FOR RECYCLED MATERIALS

Flexibility	• **different types of containers and vehicles for different recycled materials?** • **Number of trucks and containers** • **Meet the client's requirements** • **Response time**
Market Relationships	Are they tied to only one or a few markets, or do they work with many markets? Will they work with markets that you identify?

Reliability	• Check with other people they've worked with. Do they show up on time, and call if there are going to be any problems? • Do they have backup if a truck or another piece of equipment breaks down?
Location	Where are they located compared to the job site and to markets? Longer hauls mean more cost and more possibilities for things to go wrong?
Cost	What is their price structure? Be sure to comparison shop, because proposed rates can vary by 30% or 40% for the same haul.
Safety	Ask for documentation of safety and driving violations

Table 4 - What to Look For In A Hauler For Recycled Materials

WHAT TO LOOK FOR IN A MARKET FOR A RECYCLED MATERIAL

Process and End Products	**Be sure you're comfortable that their recycling process and products are in line with your own recycling and environmental goals.**
Materials	How many do they handle? All other things being equal, you'd prefer to deal with fewer markets. Be sure to shop and compare
Hauling	Will they haul as well as provide a market?
Pricing	How do they compare to other markets for the same materials? Do they return revenues for materials like metals? Are prices tied to published indexes?
Financial History	Check credit references and other sources of information to verify stability
Tracking/Reporting	certificates of recycling, or other documentation you need to confirm recycling quantities, rates, and ultimate end uses.
Safety and Environmental Record	Do an on-site audit. Look for safety and environmental issues (availability of safety equipment, general neatness, attitudes toward safety/environment, etc.)
Insurance	Confirm that insurance is in place, adequate, and paid up.

Table 5 - What To Look For In A Hauler For Recycled Materials

Building Materials – Major components

- Cement concrete
- Bricks
- Cement plaster
- Steel (from RCC, door/window frames, roofing support, railings of staircase etc.)
- Rubble
- Stone (marble, granite, sand stone)
- Timber/wood (especially demolition of old buildings)

Building Materials – Minor components

- Conduits (iron, plastic)
- Pipes (GI, iron, plastic)
- Electrical fixtures (copper/aluminium wiring, wooden baton
- bakelite/plastic switches, wire insulation)
- Panels (wooden, laminated)
- Others (glazed tiles, glass panes)

STORAGE OF CONSTRUCTION AND DEMOLITION WASTE

- should be stored within the site
- keep the waste segregated into different heaps , further gradation and reuse is facilitated
- Segregation – reused in the site, sold / refilled
- Local body should provide required containers
- Public projects –special provision for storage of wastes

COLLECTION AND TRANSPORTATION

- Skipp lifters, trailers, tractors (manual loading and unloading – last option)
- For small generators of construction debris, e.g., petty repair/maintenance job, there may be two options –
  (i) specific places for such dumping by the local body
  (ii) removal on payment basis.

RECYCLING AND REUSE

- **Reuse (at site)** of bricks, stone slabs, timber, conduits, piping railings etc. to the extent possible and depending upon their condition.
- **Sale / auction of material** which can not be used at the site due to design constraint or change in design.
- Plastics, broken glass, scrap metal etc. can be used by **recycling industries**.
- Rubble, brick bats, broken plaster/concrete pieces etc. can be used for **building activity**, such as, leveling, under coat of lanes where the traffic does not constitute of heavy moving loads.
- Larger unusable pieces can be sent **for filling up low-lying areas**.
- Fine material, such as, sand, dust etc. can be used as cover material over **sanitary landfill**.

INSTITUTIONAL AND REGULATORY ASPECTS – FOUR OPTIONS

- The total activity may be **contracted** out.
- Only **vehicles** may be **leased** out by the civic body to the private contractor for transport of debris with his own labour, i.e., labour contract.
- The vehicles may be **hired** by the local body from private sources for transport of debris with municipal labour.
- The total activity may be carried out by the LOCAL BODY.

Material	Description and Sources	Markets	Limitations on Recycling
Brick	Largely from demolition and renovation. Limited waste from new construction.	High-value re-use markets for some brick. Used in aggregate production.	Few limitations.
Concrete, Formed	Largely from demolition and renovation. Limited waste from new construction.	Mixed aggregate markets with brick and block. Used in aggregate production.	Concrete w/ rebar typically must be separated from brick, block, and concrete w/out rebar.
Concrete Block	Largely from demolition and renovation. Limited waste from new construction.	Mixed aggregate markets with brick and concrete.	Few limitations.
Metals, Ferrous	Structural and framing steel from demolition. Framing scrap from new construction and renovation.	Scrap markets; used in production of new steel.	Few limitations.
Metals, NonFerrous	Aluminum, copper, brass and alloys from electric, plumbing, and HVAC. Often significant scrap in new construction.	Scrap markets. Highest value if separated by metal at point of generation. Can be mixed and marketed with ferrous metals.	Few limitations.
Wood, Engineered	Significant quantities from new construction and renovation as well as demolition.	Some re-use value through deconstruction. Most is recycled as boiler fuel.	Generally few limitations.
Gypsum Wallboard	Clean scrap from renovation and new construction.	Currently no markets for demolition wallboard.	Clean scrap from new installation only, without tape, nails, screws, corner bead.
Ceiling Tiles	Largely from demolition and renovation.	Recyclable with considerable quantity	Subjected to test before recycling

	Generally limited waste from new construction.		
Roofing, Metal	Large quantities from demolition and renovation.	Scrap markets.	Few limitations.
Carpet	Large quantities from replacement, demolition, renovation. Significant scrap from new installation.	Carpet is taken apart into multiple materials which are then recycled separately	Carpet must be dry and mold free. Cost is typically very high.
Mixed Debris	Large quantities from demolition and renovation. Small to large quantities from new construction, depending on feasibility of source separation	Sorted mechanically and/or by hand into constituents, typically wood, metal, aggregate, and residual.	Recycling rates typically less than source separated, and costs are typically higher.

Table 5 - Institutional and Regulatory Aspects – Four Options

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT – II – Sustainable Waste Management – SARA5332

II. UNIT 2

Solid Waste Management in India

Rapid urbanization, urban growth and economic development have not only changed the physical size of the cities but is also exerting significant additional pressure on the infrastructural services across Indian cities. India is experiencing high urbanization, currently 31 percent as per Census 2011, contributing to 11 percent of the world population and having 53 metropolitan cities which may jump to 87 in 2031. Urban growth is phenomenal and important for the development of the country but unbridled growth may present a glimpse of chequered pockets of ghettos and high class areas (Gupta, 2015). These factors influence consumption rates that accelerate waste generation and change waste composition. The increasing trends in per capita waste generation puts immense pressure on urban local bodies (ULBs) who are mandated to provide this service in India. It is observed from the recent research that most ULBs are unable to handle such huge quantities of solid waste due to financial and institutional debilities. While, daily collection efficiency is around 50-60 percent and 90 percent in few ULBs, only 10 percent of the collected waste receives treatment and virtually nothing is scientifically disposed in engineered landfills(NIUA, 2013). Indian cities are facing the problem of limited availability of land for waste disposal especially in large cities. Furthermore, the ULBs rarely have sufficient funds, resources, infrastructure and appropriate strategies which have resulted in poor collection, transportation, treatment and safe disposal of solid waste. Recognizing these challenges, the Indian government and key stakeholders have been deliberating upon mechanisms and arrangements to facilitate compliance of ULBs with requirements for treatment and safe disposal of solid waste (MoUD, n.a). The two ministries of Government of India namely, the Ministry of Environment, Forest and Climate Change (MEF&CC) and the Ministry of Urban Development (MoUD) have initiated several policies and programmes to improve the current scenario of solid waste management (SWM) system in India. The Environment Ministry had promulgated the Municipal Solid Waste Management Rules in 2000 which is now being revamped as Solid Waste Management Rules 2015 while the MoUD has prepared a draft manual on MSWM to support cities and towns on planning and implementing a proper MSWM system in line with the SWM Rules being promulgated in 2015. While the MSWM Rules2000 prescribed the manner in which the authorities have to undertake solid waste management activities within their jurisdiction,it was observed that it failed to achieve its objectives due to lack of clarity, awareness among the stakeholders and poor enforcement by the regulators. The present paper is an endeavour to provide a comprehensive review of the solid waste management system and most importantly highlight some major points of the government's policies and programmes required to overcome the challenges of municipal solid waste management in India. The paper has been divided into four sections. Section 1 provides the comprehensive review of the current municipal solid waste management in India including the issues and keychallenges faced by the ULBs in making MSWM more sustainable. Section 2 discusses the technological options available for the treatment and disposal of solid waste. It also highlights the government's incentives and financial supports i.e. grants and subsidies to the ULBs for the improved SWM in the country. Section 3 of the paper provides the comprehensive review of the legal and policy framework for MSWM. The gaps in the SWM Rules 2015 and suggestions on it are discussed in the last section 4 of the paper before a brief conclusion.

Section 1: Current Scenario ofMunicipal Solid Waste Management Solid waste management includes managing activities associated with collection, transportation, treatment and disposal of solid waste in an environmentally compatible manner with due consideration of the principles of economy, aesthetics, energy and conservation. These activities are briefly discussed in the following section: 1.1 Municipal solid waste generation According to the Central Pollution Control Board (2015), India

generated1,43,449 tons per day (TPD)of municipal solid waste during 2014-15, with an average waste generation of 0.11 kg/capita/day (GIZ, 2015).It does not include waste picked up by Kabadiwalas from households and from the streets by rag pickers. Whereas according to the report of the Task Force on Waste to Energy (WtE), (2014) of the Planning Commission, the 7935 urban centres of India generate 1,70,000 TPD i.e. 62 million tons of MSW annually. It is observed that there is conflicting data about the actual quantum of waste generation in urban India because there is no system of periodically collecting data on waste generation.In terms of per capita, the waste generation varies between 200-300 gms/capita for small towns, 300-400 gms/capita for medium citiesand 400-600 gms/capita for larger cities as per the Planning Commission report. The increase in waste quantities has been estimated at 5 percent per annum.It is assumed that urban India will generate 2,76,342 TPD by 2021, 4,50,132 TPD by 2031 and 11,95,000 TPD of MSW by 2050. (Planning Commission, 2014).The physical and chemical characteristics of solid waste vary depending on population size and consumption pattern.As per the report, MSW constitutes 51 percent of organic waste, followed by the inert and non-organic waste at 32 percent. Plastics, paper, and glass constitute 17 percent of waste which are classified as recyclable wastes. The report of the Earth Engineering Centre (2012) stated that the calorific value of the waste taken largely from 7 large metropolises varied between 6.8-9.8 MJ/Kg (1620-2340 Kcal/kg.).Waste from smaller cities have low calorific value mostly less than 800Kcal/kg. It is known that a calorific value of over 2800 Kcal/kg is required for feasible incineration. The report of planning commission highlights that the plastic waste including composites are high calorific value material and crucial ingredient for MSW based WtE plants. Chintan and many other reports show that plastics are the most preferred items for retrieving by waste pickers, from garbage, since they are light weight and plastics like HDPE, LDPE and PP fetch good prices. However, extremely light weight plastics like plastic carry bags or very highly soiled plastics may be left behind in the garbage because of their low price potential. For improving the recycling of plastic waste, the Ministry of Environment, Forest and Climate Change notified "The Plastic Waste (Management and Handling) Rules, 2011" in supersession of the "Recycled Plastic Manufacture and Usage rules, 1999" notified under the Environment (Protection) Act, 1986. This is again being revamped as Plastic Waste Management Rules 2015. "Rule 6 of the said rules mandates that a plastic waste management system be put in place and identifies municipal authority as the agency responsible for implementation of the said rules within their jurisdiction". 1.2 Solid waste collection The latest report of the Planning Commission (2014) shows that as high as 68 percent of the waste generated is collected daily in India while according to the report of MoUD (2011), this percentage varies between the different sizes of cities, i.e. 70-90 percent in larger cities and less than 50 percent in smaller cities. It is observed that the collection efficiency of MSW in cities and towns is low due to non-uniformity in the collection system. Nearly 100 percent collection is observed in only those areas where the private contractors and NGOs are engaged in the waste collection activity. Uncollected waste often lies outside the designated bins in most of the urban areas due to inappropriate design, capacity, location and poor attitude of the community towards using bins. It is observed that the uncollected waste is generally burnt in open areas or on the streets. The report of the planning commission shows that over 81 percent of MSW annually is disposed at open dump sites without any treatment. Are port of Earth Engineering centre shows that "such open burning of MSW and landfill fires together releases 22,000 tons of pollutants into lower atmosphere of Mumbai city every year". It is worthwhile to note that the segregation of waste at the door step is almost absent although door to door waste collection is improving in some cities of India. Recognizing the need to adopt innovative strategies for sustainable solid waste management, many ULBs have started door to door waste collection, zero waste management, and segregation of waste at source in their cities. Success Stories Research documents reveal that 100 percent door to door waste collection has been achieved in 329 cities of Goa, Gujarat, Karnataka, Madhya Pradesh, Mizoram, Nagaland, Odisha, Sikkim, Tamil Nadu and Telangana. It is further proposed in 1000 cities for the year 2015-16. In Goa, self-help groups are involved in the entire Margoa Municipal Council. The Kochi Municipal

Corporation has successfully implemented a bin-less system in a few wards of the city (Manual: MoUD, 2014).

Pune Municipal Corporation (PMC) has initiated door to door waste collection under SWaCH programme. In 2008, the PMC signed a five year Memorandum of Understanding to decentralize door to door collection services for households, shops, offices and small commercial establishments and to allow SWaCH members to carry out this work. As part of its support, the Corporation provides uniforms, aprons, raincoats and shoes for waste pickers involved in door to door waste collection as well as other equipment such as brooms and cycle rickshaws. At present, there are 2,300 waste pickers who collect garbage from 4 lakh properties with an average of 174 properties per waste picker. The Cooperative members collect user charges ranging between Rs.10/- to Rs.30/- per household per month from the service users. The advantage of SWaCH model is that it helps the PMC collect waste from door step, is cost effective, leads to high-resource recovery, is labour-friendly using existing workers and is a sustainable enterprise (NIUA, 2013). In Surat, a door to door waste collection system by a private operator introduced in 2004has been successful. The system is operated on a PPP model with a 10 year concession period. The operator uses closed body vehicles equipped with vehicle tracking system. About 60 percent of total municipal solid waste is being collected and transported by the private operator by using 310 vehicles in the respective zones (Swachh Bharat Newsletter MoUD,2015). The Shimla Municipal Corporation formed a society known as 'Shimla Environment Heritage Conservation and Beautification' (SEHB) in 2009. The scheme was operationalized in April 2010. Personal protective equipment like rain coats, gum shoes and gloves have also been given to all sanitary staff (Bharti, 2013). The challenges of this system is mixing of wet and dry waste along with household e-waste and biomedical waste. Vehicle break-down, foul smell and spillage due to improper collection/transportation and inefficient monitoring of routes and operator are other issues that need to be addressed in Shimla. Another initiative 'Zero Waste' system has been adopted by Pune, Ahmedabad, Namakkal, etc. In Pune, the Zero Waste project at Katraj ward No. 141 was undertaken in association with NGO, Janwani. The Corporation banned open dumping in June 2010 and all disposals are done using scientific processing only. There are five decentralized waste processing plants across the city. PMC has activated a new mobile SMS alert system for timely and effective complaint redressal regarding garbage containers. The sustainability of this system relied on household and commercial properties for the segregation of waste. This type of model is first in India that received ISO certification for solid waste collection and transportation. After successful implementation of this model, it was decided to replicate this model in 20 selected prabhags (electoral ward) in a phased manner. Work on the implementation of the first phase has already begun (Swachh Bharat Newsletter, MoUD, 2015). Ahmedabad has signed Memorandum of Understanding (MoU) with United Nations Centre for Regional Development, Japan towards making Ahmedabad a zero waste city. To achieve this objective, Ahmedabad Municipal Corporation is working closely with Urban Management Centre (UMC) for developing Master Plan, City Sanitation Plan, mainstreaming waste pickers and creating citizen awareness (NIUA, 2013). 1.3 Transfer station and transportation Transfer stations are used where disposal sites are more than 10 km away from the city. To save transportation time and fuel such cities have a good performance record of vehicle maintenance and adequate facilities to maintain large size vehicles and containers. Ramp facility is provided to facilitate uploading of the dumper placer containers directly into a large container at the transfer stations. If there is an issue of suitable land for a permanent station then mobile compactor truck with primary collection vehicles can be used to improve the transportation efficiency of the system (MoUD, 2012). Such stations have been effectively used in Surat, and Coimbatore. There are six transfer stations in Surat and all are operational. Waste collected is transported to transfer stations through private vehicles and finally sent to the disposal site for waste disposal. Containers are fully closed with leak proof doors. The achievements of the transfer station model are (i) the municipal waste received through closed vehicles are dropped into closed containers without secondary handling; (ii) covered leak proof containers prevent spillage of waste on the road; (iii) no permanent

or temporary storage at transfer stations, thus averting the nuisance of flies and animals at transfer stations; and (iv) separate leachate collecting system is provided. Coimbatore Municipal Corporation has four transfer stations namely Peelamedu (200 TPD), Sathy Road (125 TPD), Ukkadam (200 TPD) and Ondipudur
(125 TPD). All these transfer stations are operational. At present, although there are different types and sizes of vehicles used for transportation of waste such as dumper placers/schiff loaders, refuse collector without compactor, refuse collection mobile compactors, mini truck with tipping floor, hook loader/hook lifter, the selection of the type of vehicles depends on various factors such as the quantity of waste, distance, road widths and conditions and process technologies. To save travel time, minimize human errors and improve the monitoring system, many ULBs have installed Global Positioning System (GPS), Geographic Information System (GIS), and Global System for Mobile Communication (GSM) system in their trucks to collect waste from secondary sources for the disposal of waste. The Tool Kit for Solid Waste Management prepared by the MoUD reveals that municipalities like PimpriChinchwad, Hyderabad and Delhi have benefitted from this system. Ensuring the efficiency of 100 percent waste collection is still a big challenge for the ULBs despite these technologies. Another significant challenge is to deal with corruption and lack of commitment in the solid waste transport sector. Section 2: Technologies for treatment of solid waste 2.1 Technologies for MSWM At present, there are a number of processing technologies such as composting, bio-methanation, recycling, refuse derived fuel (RDF), gasification, incineration, pyrolysis, engineered landfills etc., available for the treatment of municipal solid waste. However, each of the technologies may have positive as well negative implications. The selection of suitable technologies depends on the population of a city and quantity of waste. It is important to note that "the biggest constraints lie in separating, collecting and transporting this component to the location where decentralized or centralized large scale composting or biogas generation plus composting can be carried out" (Mani, 2015).Efficiency of recycling and composting is greatly reduced due to the absence of source separation. Research documents show that over 50% of waste collected is biodegradable organic material which can be used for compositing or used for generating biogas. This wet waste must be processed either through biomethanation or composting technology for generating biogas, electricity and compost for use as nutrient and prevent such wastes from reaching the landfill. Reusable and recyclable waste that constitute 18-20 percent of the total waste are not separated because the process of separating them from mixed waste is highly energy and time intensive and is generally not carried out. However, the recycling industries face a number of problems such as (i) these industries being labour intensive, (ii) and the poor quality of recycled products are not compliant with regulatory requirements. Mixed waste can neither be recycled nor composted. The report of the Task Force on Waste to Energy (Vol.I), 2014 reveals that "only 22 states/UTs have set up processing and disposal facilities and the rest of the States/UTs had made no effort till 2013. Of the 279 conventional composting, 138 vermi composting facilities, 172 biomethanation, 29 RDF and 8 Waste to Energy plants reported to have been established many are either closed or underperforming". 2.2 Disposal of MSW Waste dumps or open burning continue to be the principal method of waste disposal in India. These methods are continuous sources of harmful gases and highly toxic liquid leachate. Most of the cities and towns dispose of their waste by depositing it in low-lying areas outside the city without taking precautions. As per the estimates made by the Planning Commission (2014), more than 80 percent waste collected is disposed indiscriminately at dump yards in an unhygienic manner by the municipal authorities leading to health and environmental degradation. Limited availability of land for waste disposal is a major cause of the MSW mess especially in big cities. The position paper on the SWM in India of the Ministry of Finance, 2009 estimates a requirement of more than 1400 sq.km. of land for the solid waste disposal by the end of 2047 if MSW is not properly handled. The draft SWM Rules, 2015 provides criteria for the location of sanitary landfills. "Guidelines for the Selection of Site for Landfilling from the CPCB should also be consulted". Finding new landfill sites is a major constraint including the 'not in my

backyard' (NIMBY) phenomenon. People want a good facility for MSW but not in the vicinity of their households. The NIMBY attitude of the people has made the task difficult for the ULBs with respect to waste storage.

2.3 Financial Supports and Incentives In order to give a push to MSWM in cities, the Central government has sanctioned the 12th and 13th Finance Commission Grants and Funds for the improvement of MSW under flagship projects like JnNURM, UIDSSMT from 2005 onwards and the recent Swachh Bharat Mission (SBM). The 12th Finance Commission had allocated Rs.25,000 crore (Rs.20,000 crore for Panchayat and Rs.5,000 crore for ULBs) for supplementing the resources of the ULBs during the period 2005-2010. Under the 12th Finance Commission (FC), an award of Rs.2,500 crore was made available to ULBs of all class I cities for SWM during the period 2005-10. A substantial incentive grant of Rs. 5000 crore was recommended by the 13th FC for grid-connected renewable energy based MSWM on the states' achievement in renewable energy capacity during April 2010 to March 2014. According to the Tool Kit for SWM (2012),SWM should have been treated as a specific and exclusive project, which requires large capital investment as well as operation and maintenance cost. The estimates of the High Powered Expert Committee of MoUD, 2011 reveals that the per capita investment cost and per capita operations and maintenance cost for SWM both are highest in Class IA cities (Rs.900/- and Rs.269/- per year respectively) as compared to other classes (IB, IC and Class II and Class III) due to the assumption that large cities would adopt highly mechanized systems while smaller cities would adopt comparatively more labour intensive processes while Class III and IV cities would adopt lowest technologies. The Ministry of Environment, Forest and Climate Change also provides financial support of upto 50 percent of the capital cost to set up pilot demonstration plants on MSW composting. The Ministry also extends limited financial assistance for waste characterization and feasibility studies. The Ministry of New and Renewable Energy (MNRE) has designed schemes to promote waste to energy projects. The Ministry also promotes all technological options for setting up projects for recovery of energy from urban, industrial and agricultural wastes. Currently only five pilot projects based on MSW to energy are being supported. Under this scheme, a minimum amount of Rs.2 crore and a maximum of Rs. 10 crore per project are available as capital subsidy. The entire capital subsidy amount is released to the beneficiary's loan account. Some of State governments of Andhra Pradesh, Haryana, Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Rajasthan, Tamil Nadu and Uttar Pradesh have announced policy measures pertaining to allotment of land, supply of garbage, and facilities for evacuation, sale and purchase of power to encourage the setting up of waste to energy projects. Land for the facilities is provided by the ULB at a nominal rent. Although recent announcement by the Power Ministry to purchase power generated from WTE plants at a higher rate than earlier, the cost of monitoring and mitigating emissions and pollutants from such incineration based WTE plants has made them unviable. Greater incentivization and operational support is required for promoting biomethanation based WTE. Swachh Bharat Mission is currently making available Viability Gap Funding (VGF) upto 20% to states and individual municipal corporations. However, ULBs are still not able to raise the rest of 80% investment required for SWM improvement in their cities and towns. Greater convergence of schemes and sustainable models need to be explored. 3. Legal and policy framework for MSWM 3.1 SWACHH Bharat Mission One of the important declaration in the development agenda of NDA government is that of Open Defecation Free India by 2019. The "Swachh Bharat Mission" (SBM) is a major initiative of the Ministry of Urban Development (MoUD), Government of India. It is launched on the occasion of the birth anniversary of Mahatma Gandhi on 2nd October, 2014. The Mission is a national campaign covering 4041 statutory towns to clean the streets, roads and infrastructure of the country. Solid waste management is one of the important components of the Mission. The national government has allocated of Rs.14,623 crore for the SBM for urban areas, of which Rs.7,366 crore is given for the SWM for five years i.e. 2014-2019. While addressing the components of SBM for urban areas, state governments and ULBs are expected to focus on a set of

social priorities and outcomes that define the scope and complexity of the Mission.
3.2 Municipal Solid Waste (Management and Handling) Rules-2000 According to the Indian Constitution, the SWM is a state subject and included in the 12th Schedule of the Constitution (74th Amendment) Act of 1992, ULBs are mandated to provide MSWM. State laws governing the ULBs also stipulate MSWM as an obligatory function of the municipal governments. Despite 15 years of implementation of these Rules, ULBs have not been able to put in place good systems. Wherever the people's representatives along with the people have supported source segregation, door to door collection and eco-friendly friendly treatment of the segregated components in waste, they have been able to solve the issue with regard to processing and disposal of solid waste. At present, the MSW Management and Handling Rules 2000 are under revision by MoEF&CC. The draft revised rules was circulated in 2013 and again in 2015 and will be finalized as Solid Waste Management Rules 2015. It lays down the mandatory functions to be performed by various stakeholders. Significantly, the new Rules not only emphasize source separation of wet, dry and hazardous waste and their separate treatment but specifically Construction and Demolition (C&D) waste for separation and treatment as a separate chapter. Similarly the new Plastic Waste, E-waste, Fly-Ash and Bio-medical waste Management Rules are under revision and will be promulgated in 2015. 3.3 Draft Manual on Municipal Solid Waste Management The Central Public Health & Environmental Engineering Organization (CPHEEO), Ministry of Urban Development, Government of India has prepared a draft manual on MSWM to support cities and towns on planning and implementing a proper MSWM system in line with the SWM Rules being amended in 2015. This manual addresses the all aspects of MSWM namely, planning, technical, institutional, financial and legal dimensions. According to the manual, the MSWM plan should address the five year short term plan and long term periods from 20-25 years. "The five-year short term plan may be broken into specific action plans, covering various aspects such as institutional strengthening, community mobilization, waste minimization initiatives, waste collection and transportation, treatment and disposal and other policy changes as may be deemed necessary". 4. Gaps and Suggestions on the Draft SWM Rules 2015 The MoEFCC published the draft SWM Rules 2015 in their website in May 2015 and requested stakeholders throughout India to send their comments and suggestions. The authors examined the draft SWM Rules 2015 to identify gaps and make suggestions. These are discussed in the following paragraphs. Gaps in the draft SWM Rules 2015 1. Although separate categories have been specified for wet, dry, hazardous and C & D wastes, a separate category for sanitary waste is missing. 2. GPS/GIS system for tracking trucks carrying separated waste needs to be emphasized. 3. Synchronization of secondary storage containers and vehicles with transportation is difficult because traffic congestion and pollution from waste collection vehicles plying during peak hours is an issue. 4. Use of user fee charges need to be spelt out especially for the first mile SWM – payment to waste collectors' collectives for door to door collection, decentralized composting, recycling etc. 5. Horticultural waste needs separate processing. Similarly, prohibiting burning of leaves and garden waste needs emphasis. 6. Compliance criteria for Material Recovery Facilities (MRF) and use of Personal Protective Equipment (PPE) for door to door collection and secondary segregation need to be delineated. 7. Responsibility of processing domestic hazardous waste is left to SPCBs instead of making it mandatory to be transported to regional secured landfills and treatment like TSDFs worked out. 8. Knowhow and technologies are not available with ULBs for bio-mining and bio-remediation and action. This should be done through SPVs after proper EIAs etc.

Suggestions to improve proposed SWM Rules 2015 1. Greater emphasis on recycling is required. ULBs especially smaller ones can easily form cooperatives etc. with waste collectors initiatives and collectives for recycling rather than tie-ups with large companies for setting up incineration plants. 2. Recycling technologies for making structural from plastics or converting waste plastics and non-recyclables to Light Diesel Oil as mentioned in the Planning Commission report 2014 should be delineated and their standards prescribed. This is feasible in smaller ULBs also. 3. Waste to energy

Plants based on incineration are still being tested. For smaller ULBs, the cost of incineration plus pollution control is prohibitive. 4. Much greater emphasis on ULBs working with waste pickers collectives and NGOs for setting up door to door collection of segregated waste, Material Recovery Facilities (MRFs) and secondary segregation while providing Personal Protective Equipment (PPE) to them is required. 5. Sanitary and household Biomedical waste management should have a separate section. Sanitary waste collection from doorstep every two days in red colour bags and transporting sanitary and biomedical waste generated in homes and non-medical institutions to Common Biomedical Waste Treatment Facilities (CBWTFs) should be made mandatory. 6. Flushing of gel based napkins should be banned and separate collection emphasized. It can be said that Draft SWM Rules 2015 are a big step forward but they do not address all the concerns and need to be improved if they have to play an important role in improving waste management and sanitation conditions in our country. Conclusion: Overall, the policy agenda for Sustainable Solid Waste Management (SSWM) needs to drive behavioural change among citizens, elected representatives and decision makers to minimize wastage and littering and maximize reuse and recycling. SSWM is a people management issue and over-emphasis of technological solutions to solving the SWM problem will only delay in realizing good results.

Challenges and opportunities associated with waste management in India

Introduction

Solid waste management (SWM) is a major problem for many urban local bodies (ULBs) in India, where urbanization, industrialization and economic growth have resulted in increased municipal solid waste (MSW) generation per person . Effective SWM is a major challenge in cities with high population density. Achieving sustainable development within a country experiencing rapid population growth and improvements in living standards is made more difficult in India because it is a diverse country with many different religious groups, cultures and traditions.

Despite significant development in social, economic and environmental areas, SWM systems in India have remained relatively unchanged. The informal sector has a key role in extracting value from waste, with approximately 90% of residual waste currently dumped rather than properly landfilled . There is an urgent need to move to more sustainable SWM, and this requires new management systems and waste management facilities. Current SWM systems are inefficient, with waste having a negative impact on public health, the environment and the economy . The waste Management and Handling Rules in India were introduced by the Ministry of Environment and Forests (MoEF) , although compliance is variable and limited.

This paper reviews the challenges, barriers and opportunities associated with improving waste management in India. It is the output from an international seminar on ‘Sustainable solid waste management for cities: opportunities in SAARC countries' organized by the Council of Scientific and Industrial Research-National Environmental Engineering Research Institute (CSIR-NEERI) and held in Nagpur, India in 2015. SAARC is the South Asian Association for Regional Cooperation and includes Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka and Afghanistan.

Waste generation in India

India is experiencing rapid urbanization while remaining a country with physical, climatic, geographical, ecological, social, cultural and linguistic diversity The population of India was 1252

million in 2013, compared with 1028 million in 2001 Population growth is a major contributor to increasing MSW in India.

Growth of mega cities in India

Megacities are a relatively recent phenomenon, associated with globalization of the economy, culture and technology Megacities in India include Ahmedabad (6.3 million), Hyderabad (7.7 million), Bangalore (8.4 million), Chennai (8.6 million), Kolkata (14.1 million), Delhi (16.3 million) and Greater Mumbai (18.4 million []. These have dynamic economic growth and high waste generation per capita,

Infrastructure development for public health and protection of the environment

Improvements in civil infrastructure are required for India to become a world leading economy. Developing high-quality infrastructure that meets the needs of the people and protects the environment is fundamental to achieving effective economic growth . Waste management infrastructure has an important role in delivering sustainable development. Rapid population growth in India has led to depletion of natural resources. Wastes are potential resources and effective waste management with resource extraction is fundamental to effective SWM. Value extraction from waste can be materials, energy or nutrients, and this can provide a livelihood for many people The transition from wastes to resources can only be achieved through investment in SWM as this depends on a coordinated set of actions to develop markets and maximize recovery of reusable/recyclable materials . Materials, energy and nutrient recovery must be the aim of future SWM infrastructure development in India. Resources can be recovered from wastes using existing technologies and India has an extremely effective recycling tradition. The ‘scrap dealer’ systems produce recycled materials through an extensive and well-coordinated network across the country.

Statistics on waste generation and waste characterization data

Estimating the quantity and characteristics of MSW in India and forecasting future waste generation is fundamental to successful waste management planning . The quantity of MSW generated depends on living standards, the extent and type of commercial activity, eating habits and season . India generates approximately 133 760 tonnes of MSW per day, of which approximately 91 152 tonnes is collected and approximately 25 884 tonnes is treated MSW generation per capita in India ranges from approximately 0.17 kg per person per day in small towns to approximately 0.62 kg per person per day in cities .

Waste generation rate depends on factors such as population density, economic status, level of commercial activity, culture and city/region. Figure 1 provides data on MSW generation in different states, indicating high waste generation in Maharashtra (115 364–19 204 tonnes per day), Uttar Pradesh, Tamil Nadu, West Bengal (11 523–15 363 tonnes per day), Andhra Pradesh, Kerala (7683–11 522 tonnes per day) and Madhya Pradesh, Rajasthan, Gujarat, Karnataka and Mizoram (3842–7662 tonnes per day). Lower waste generation occurs in Jammu and Kashmir, Bihar, Jharkhand, Chhattisgarh, Orissa, Goa, Assam, Arunachal Pradesh, Meghalaya, Tripura, Nagaland and Manipur (less than 3841 tonnes per day).

Waste characterization data

The local economy impacts on waste composition, as high-income groups use more packaged products, resulting in higher volumes of plastics, paper, glass, metals and textiles. Changes in waste composition can have a significant impact on waste management practices . MSW may also contain hazardous wastes such as pesticides, paints, used medicine and batteries. Compostable organics include fruits, vegetables and food waste. Healthcare waste contains disposable syringes, sanitary materials and blood containing textiles and is governed by the Biomedical Waste (Management and Handling) Rules 1998 and the Amended Rules, 2003, and should not be mixed with MSW .The average composition of MSW produced by Indian cities is approximately 41 wt.% organic, approximately 40 wt.% inert, with approximately 19 wt.% potentially recyclable materials. Most organic waste is generated from households, and inert waste is generated from construction, demolition and road sweeping. Waste samples collected from Delhi, Ahmadabad and Bangalore indicate that MSW composition varies between cities

Predictions on future waste growth

World waste production is expected to be approximately 27 billion tonnes per year by 2050, one-third of which will come from Asia, with major contributions from China and India . Waste generation in urban areas of India will be 0.7 kg per person per day in 2025, approximately four to six times higher than in 1999. The problems associated with waste become more acute as the size of communities increase and this provides opportunities for decentralized waste management by self-help groups and NGOs . The waste produced in urban areas of India is approximately 170 000 tonnes per day, equivalent to about 62 million tonnes per year, and this is expected to increase by 5% per year owing to increases in population and changing lifestyles . Table 5 shows that urban India generated 31.6 million tonnes of waste in 2001 and is currently generating 47.3 million tonnes. By 2041, waste generation is predicted to be 161 million tonnes, a fivefold increase in four decades

. Current waste management in India

Key waste management legislations in India

The MoEF issued MSW (Management and Handling) Rules 2000 to ensure proper waste management in India and new updated draft rules have recently been published . Municipal authorities are responsible for implementing these rules and developing infrastructure for collection, storage, segregation, transportation, processing and disposal of MSW. Chandigarh is the first city to develop SWM in a planned way and has improved waste management compared with other Indian cities

Role of the informal sector in waste materials reuse and recycling

The informal sector has a very important role in India and this must be integrated into formal SWM systems . The informal sector is characterized by small-scale, labour-intensive, largely unregulated and unregistered low-technology manufacturing or provision of materials and services Waste pickers collect household or commercial/industrial waste and many hundreds of thousands of waste pickers in India depend on waste for an income, despite the associated health and social issues. Pickers extract potential value from waste bins, trucks, streets, waterways and dumpsites. Some work in recycling plants owned by cooperatives or waste picker associations. Waste picking is

often the only source of income for families, providing a livelihood for significant numbers of urban poor and usable materials to other enterprises. Waste pickers in Pune collect organic waste for composting and biogas generation. Waste pickers also make a significant contribution by keeping cities clean.

A recent study of six Indian cities found that waste pickers recovered approximately 20% of waste, with 80 000 people involved in recycling approximately three million tonnes. It is estimated that every tonne of recyclable material collected saved the ULB approximately INR 24 500 per annum and avoided the emission of 721 kg CO2 per annum .

Waste collection and transport

Waste collection, storage and transport are essential elements of any SWM system and can be major challenges in cities. Waste collection is the responsibility of the municipal corporations in India, and bins are normally provided for biodegradable and inert waste . Mixed biodegradable and inert waste is often dumped, with open burning a common practice. Improvements to waste collection and transport infrastructure in India will create jobs, improve public health and increase tourism Local bodies spend around Rs. 500–1000 per tonne on SWM with 70% of this amount spent on collection and 20% spent on transport.

Waste disposal

SWM disposal is at a critical stage of development in India. There is a need to develop facilities to treat and dispose of increasing amounts of MSW More than 90% of waste in India is believed to be dumped in an unsatisfactory manner. It is estimated that approximately 1400 km2 was occupied by waste dumps in 1997 and this is expected to increase in the future,

Environmental and health impacts of waste dumping

Waste dumps have adverse impacts on the environment and public health . Open dumps release methane from decomposition of biodegradable waste under anaerobic conditions. Methane causes fires and explosions and is a major contributor to global warming . There are also problems associated with odour and migration of leachates to receiving waters . Odour is a serious problem, particularly during the summer when average temperatures in India can exceed 45°C . Discarded tyres at dumps collect water, allowing mosquitoes to breed, increasing the risk of diseases such as malaria, dengue and West Nile fever. Uncontrolled burning of waste at dump sites releases fine particles which are a major cause of respiratory disease and cause smog . Open burning of MSW and tyres emits 22 000 tonnes of pollutants into the atmosphere around Mumbai every year . The impacts of poor waste management on public health are well documented, with increased incidences of nose and throat infections, breathing difficulties, inflammation, bacterial infections, anaemia, reduced immunity, allergies, asthma and other infections .

Engineered landfills in India

The UN Environmental Programme defines landfill as the controlled disposal of MSW on land in such a way that contact between waste and the environment is significantly reduced, with waste disposal concentrated in a well-defined area. Engineered landfill allows the safe disposal of residual MSW on land, but protects ground and surface water from pollution and avoids air emissions, wind-blown litter, odour, fire hazards, problems with animals, birds and other pests/rodents, and

reduces greenhouse gas (GHG) emissions and slope instability issues . Properly managed engineered landfills should replace dumps in India. This would significantly reduce the environmental impact of waste .

Waste-to-energy in India

The problems associated with improper waste disposal could be significantly mitigated by requiring material recovery. Source separation of inert and high moisture content fractions would maximize the potential for thermal recovery and other treatment options in India. The waste processed in thermal recovery is residual waste that remains after all commercially viable recyclable materials have been extracted. Waste-to-energy technologies produce energy, recover materials and free land that would otherwise be used for dumping. The composition of residual waste is important for energy recovery and waste composition is changing in India, with the amount of high calorific waste generally increasing . A significant increase in the use of waste-to-energy technologies has been proposed, but this depends on location, climate, demographics and other socioeconomic factors .

The most widely used waste-to-energy technology for residual waste uses combustion to provide combined heat and power . Adopting maximum recycling with waste-to-energy in an integrated waste management system would significantly reduce dumping in India. Waste-to-energy technologies are available that can process unsegregated low-calorific value waste, and industry is keen to exploit these technologies in India. Several waste-to-energy projects using combustion of un-segregated low-calorific value waste are currently being developed. Alternative thermal treatment processes to combustion include gasification, pyrolysis, production of refuse derived fuel and gas-plasma technology.

Waste-to-energy development in India is based on a build, operate and transfer model. Increased waste-to-energy would reduce disposal to land and generate clean, reliable energy from a renewable fuel source, reducing dependence on fossil fuels and reducing GHG emissions. In addition, generation of energy from waste would have significant social and economic benefits for India. However, the track record of waste-to-energy in India highlights some of the difficulties. The vast majority of facilities have not worked effectively due to various operational and design problems. For example, the first large-scale MSW incinerator built at Timarpur, New Delhi in 1987 had a capacity to process 300 tonnes per day and cost Rs. 250 million (US$ 5.7 million). The plant failed because of poor waste segregation, seasonal variations in waste composition and properties, inappropriate technology selection and operational and maintenance issues . Despite this experience, waste-to-energy will have a key role in future waste management in India.

Barriers to improved waste management in India

The current status of SWM in India is poor because the best and most appropriate methods from waste collection to disposal are not being used. There is a lack of training in SWM and the availability of qualified waste management professionals is limited. There is also a lack of accountability in current SWM systems throughout India . Municipal authorities are responsible for managing MSW in India but have budgets that are insufficient to cover the costs associated with developing proper waste collection, storage, treatment and disposal. The lack of strategic MSW plans, waste collection/segregation and a government finance regulatory framework are major barriers to achieving effective SWM in India.

Limited environmental awareness combined with low motivation has inhibited innovation and the adoption of new technologies that could transform waste management in India. Public attitudes to waste are also a major barrier to improving SWM in India.

Changes required to improve waste management in India

Core to the vision for waste management in India is the use of wastes as resources with increased value extraction, recycling, recovery and reuse. ULBs need to be responsible for waste management, with the ULB Commissioner and Chairman directly responsible for performance of waste management systems. Waste management needs to be regarded throughout Indian society as an essential service requiring sustainable financing. The case presented to a ULB for a properly funded system must demonstrate the advantages of sound investment in waste management.

A strong and independent authority is needed to regulate waste management if SWM is to improve in India. Without clear regulation and enforcement, improvements will not happen. Strong waste regulations can drive innovation. The waste management sector needs to include attractive and profitable businesses with clear performance requirements imposed by the ULB, with financial penalties applied when waste management services are not working effectively. Finance for waste management companies and funding for infrastructure must be raised from waste producers through a waste tax. An average charge of 1 rupee per person per day would generate close to 50 000 crores annually, and this level of funding would probably be sufficient to provide effective waste management throughout India.

Information on future quantities and characterization of wastes is essential as this determines the appropriateness of different waste management and treatment options. State-level procurement of equipment and vehicles is necessary for primary and secondary collection with effective systems for monitoring collection, transport and disposal.

Littering and waste in streets is a major problem in India that has serious impacts on public health. Nagpur has introduced a system for sweeping roads in which every employee sweeps a fixed road length. The Swatchata Doot Aplya Dari (sanitary worker at your doorstep) scheme of the Centre for Development Communication was selected as an example of good practice by UN HABITAT in 2007.

Waste management must involve waste segregation at source to allow much more efficient value extraction and recycling. Separating dry (inorganic) and wet (biodegradable) waste would have significant benefits and should be the responsibility of the waste producer.

Long-term waste management planning requires visionary project development by ULBs, the private sector and NGOs. The roles and responsibilities to deliver sustainable systems need to be defined, with monitoring and evaluation to monitor progress. Experiences should be shared between different regions of India and different social groups. There are a number of research institutes, organizations, NGOs and private sector companies working on a holistic approach to SWM, and future waste management in India must involve extensive involvement of the informal sector throughout the system.

There is a need to develop training and capacity building at every level. All Indian school children should understand the importance of waste management, the effects of poor waste management on the environment and public health, and the role and responsibilities of each individual in the waste

management system. This will develop responsible citizens who regard waste as a resource opportunity.

Population growth and particularly the development of megacities is making SWM in India a major problem. The current situation is that India relies on inadequate waste infrastructure, the informal sector and waste dumping. There are major issues associated with public participation in waste management and there is generally a lack of responsibility towards waste in the community. There is a need to cultivate community awareness and change the attitude of people towards waste, as this is fundamental to developing proper and sustainable waste management systems. Sustainable and economically viable waste management must ensure maximum resource extraction from waste, combined with safe disposal of residual waste through the development of engineered landfill and waste-to-energy facilities. India faces challenges related to waste policy, waste technology selection and the availability of appropriately trained people in the waste management sector. Until these fundamental requirements are met, India will continue to suffer from poor waste management and the associated impacts on public health and the environment.

Engineering Research Institute (CSIR-NEERI) Nagpur during 25–27 March 2015 with participation of UK and Indian SWM experts.

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III. UNIT 3

Solid Waste Management in Other Countries

INTRODUCTION • To showcase the good work that is being done on solid waste by cities around the world, large and small, rich and poor. • to look at what drives change in solid waste management, how things work in cities and what seems to work better under which circumstances. • to help decision-makers, practitioners and ordinary citizens understand how a solid waste management system works; and • to inspire people everywhere, in good communication with their neighbours, constituents and leaders, to make their own decisions on the next steps in developing a solution appropriate to their own city's particular circumstances and needs. • First and foremost, it is based on the framework of integrated sustainable waste management (ISWM), especially the concepts of sustainability and inclusive good practice that have broadened and enriched the field. • This is neither a 'how-to' book nor a 'let's fix it' book, although the discerning reader will find elements of both, but more of a 'how do they do it now and what do they need to do more or less of' kind of discussion. • The book explores both expensive 'best practice' technologies, as used in highincome countries, and moderate-cost creative alternatives that improve the environment.

THE SCALE OF THE SOLID WASTE PROBLEM
• Definitions of municipal solid waste (MSW) vary between countries, so it is important to establish at the outset just what is being discussed in this book. • A working definition is 'wastes generated by households, and wastes of a similar nature generated by commercial and industrial premises, by institutions such as schools, hospitals, care homes and prisons, and from public spaces such as streets, markets, slaughter houses, public toilets, bus stops, parks, and gardens'. • Manufacturing industries generate municipal solid waste from offices and canteens, and industrial wastes from manufacturing processes. • Some industrial wastes are hazardous and this part of the waste stream requires special management, separate from other wastes. • Small workshops in urban areas generate both municipal and process wastes, some of which may be hazardous.

• Hospitals and healthcare establishments services generate municipal solid waste fractions that include food waste, newspapers and packaging, alongside specialized healthcare hazardous wastes that are often mixed with body fluids, chemicals and sharp objects. • Construction sites generate some municipal solid waste, including packaging and food and office wastes, together with C&D wastes containing materials such as concrete, bricks, wood, windows and roofing materials. • Construction and demolition wastes from household repairs and refurbishment, particularly 'do-it-yourself' wastes, are most likely to enter the municipal solid waste stream.

The working definition implies that parallel waste management systems will exist within an urban area, one for municipal solid waste run by, or on behalf of, the municipality, and others for industrial, C&D, healthcare, end-of-life vehicles and other hazardous wastes. • Definitions also change over time. Prior to rapid modernization, when a city depends on 'open access' to uncontrolled dumping, such sites normally receive all kinds of wastes, including hazardous, industrial and healthcare wastes. • While this book acknowledges the importance of good management of specific hazardous, industrial and healthcare wastes, it addresses them only by specifically excluding them from its main areas of focus. • Substantial guidance on managing hazardous wastes is available, for example, from the Basel Convention3 and the United Nations Environment Programme (UNEP), and on managing healthcare hazardous wastes from the World Health Organization (WHO).

SPECIAL WASTE STREAMS
• Healthcare waste has become a serious health hazard in many countries. Careless and indiscriminate

disposal of this waste by healthcare institutions can contribute to the spread of serious diseases such as hepatitis and AIDS (HIV) among those who handle it and also among the general public. • development of resistant strains of microorganisms; • trade in waste materials and disposed of or expired drugs that are recovered and repacked to be sold as new; • spread of disease through contact with people or animals who pick or eat waste; • increased risk of infections and sharp injuries to hospital staff, municipal waste workers and waste-pickers; • organic pollution

Solid Waste Management i n t h e W o r l d ' s C i t i e s INTRODUCTION • To showcase the good work that is being done on solid waste by cities around the world, large and small, rich and poor. • to look at what drives change in solid waste management, how things work in cities and what seems to work better under which circumstances. • to help decision-makers, practitioners and ordinary citizens understand how a solid waste management system works; and • to inspire people everywhere, in good communication with their neighbours, constituents and leaders, to make their own decisions on the next steps in developing a solution appropriate to their own city's particular circumstances and needs. • First and foremost, it is based on the framework of integrated sustainable waste management (ISWM), especially the concepts of sustainability and inclusive good practice that have broadened and enriched the field. • This is neither a 'how-to' book nor a 'let's fix it' book, although the discerning reader will find elements of both, but more of a 'how do they do it now and what do they need to do more or less of' kind of discussion. • The book explores both expensive 'best practice' technologies, as used in highincome countries, and moderate-cost creative alternatives that improve the environment. THE SCALE OF THE SOLID WASTE PROBLEM • Definitions of municipal solid waste (MSW) vary between countries, so it is important to establish at the outset just what is being discussed in this book. • A working definition is 'wastes generated by households, and wastes of a similar nature generated by commercial and industrial premises, by institutions such as schools, hospitals, care homes and prisons, and from public spaces such as streets, markets, slaughter houses, public toilets, bus stops, parks, and gardens'. • Manufacturing industries generate municipal solid waste from offices and canteens, and industrial wastes from manufacturing processes. • Some industrial wastes are hazardous and this part of the waste stream requires special management, separate from other wastes. • Small workshops in urban areas generate both municipal and process wastes, some of which may be hazardous. • Hospitals and healthcare establishments services generate municipal solid waste fractions that include food waste, newspapers and packaging, alongside specialized healthcare hazardous wastes that are often mixed with body fluids, chemicals and sharp objects. • Construction sites generate some municipal solid waste, including packaging and food and office wastes, together with C&D wastes containing materials such as concrete, bricks, wood, windows and roofing materials. • Construction and demolition wastes from household repairs and refurbishment, particularly 'do-it-yourself' wastes, are most likely to enter the municipal solid waste stream. • The working definition implies that parallel waste management systems will exist within an urban area, one for municipal solid waste run by, or on behalf of, the municipality, and others for industrial, C&D, healthcare, end-of-life vehicles and other hazardous wastes. • Definitions also change over time. Prior to rapid modernization, when a city depends on 'open access' to uncontrolled dumping, such sites normally receive all kinds of wastes, including hazardous, industrial and healthcare wastes. • While this book acknowledges the importance of good management of specific hazardous, industrial and healthcare wastes, it addresses them only by specifically excluding them from its main areas of focus. • Substantial guidance on managing hazardous wastes is available, for example, from the Basel Convention3 and the United Nations Environment Programme (UNEP), and on managing healthcare hazardous wastes from the World Health Organization (WHO). SPECIAL WASTE STREAMS • Healthcare waste has become a serious health hazard in many countries. Careless and indiscriminate disposal of this waste by healthcare institutions can contribute to the spread of serious diseases such as hepatitis and AIDS (HIV) among those who handle it and also among the general public. • development of resistant strains of microorganisms; • trade in waste

materials and disposed of or expired drugs that are recovered and repacked to be sold as new; • spread of disease through contact with people or animals who pick or eat waste; • increased risk of infections and sharp injuries to hospital staff, municipal waste workers and waste-pickers; • organic pollution THE WORLD HEALTH ORGANIZATION: THE UNITED NATIONS AGENCY FOR HEALTH AND HEALTHCARE WASTE • The WHO focuses on healthcare waste. It supports information collection and exchange, development of national policies and training. National agencies focus on implementation of national policies, guidelines on safe practices, training and promotion of effective messages. • Effective healthcare waste management will decrease infections and also benefit visitors, and will be reflected in communities through good practices in safe water, sanitation and hygiene. • In 2002, the results of a WHO assessment conducted in 22 developing countries showed that the proportion of healthcare facilities that do not use proper waste disposal ranges from 18 to 64 per cent.

LEARNING FROM HISTORY The role of development drivers in solid waste modernization11 What have been the main driving forces for development? In parallel with industrialization and urbanization, the specific drivers for the development and modernization of waste management have related to improvement of public health, protection of the environment and (first and last) the resource value of the waste ■ Driver1:Publichealth Starting in the middle of the 19th century, as cholera and other infectious diseases reached the cities of Europe and North America, legislation was gradually introduced to address the problem of poor sanitation conditions. This legislation both established strong municipal authorities and charged them with increasing responsibility for removing solid waste and keeping streets clean and litter free. ■ Driver2:Environment The focus of solid waste management remained on waste collection, getting waste out of the city, for a century – right up to the emergence of the environmental movement during the 1960s and 1970s. New laws were introduced, first, on water pollution, and from the 1970s on solid waste management, prompted by crises of contamination of water, air and land and their impacts upon the health of those living close to abandoned hazardous waste dumps. The initial response focused on phasing out uncontrolled disposal, both on land and by burning. Subsequent legislation gradually tightened environmental standards – for example, to minimize the formation of contaminated water ('leachate') and to prevent its release into groundwater and surface water from 'sanitary landfills'; and to reduce still further urban air pollution related to the incineration of solid waste in cities. ■ Driver3:Theresourcevalueofthewaste In pre-industrial times, resources were relatively scarce, so household goods were repaired andreused. Food and garden waste entered agricultural supply chain as animal feed or fertilizer. As cities grew from the 19th century with industrialization, large numbers of people found an economic niche as 'rag-pickers' or 'street buyers', collecting and using or selling materials recovered from waste; in many cases, this activity was done by peddlers who collected rags and bones from the people to whom they sold. activity continues today – virtually unchanged – in many developing and transitional country cities, where informal-sector activities in solid waste management and recycling secure the livelihood of millions of people. ■ Emergingdriver4:Climatechange14 Since the early 1990s, climate change has directed attention in the West on the need to keep biodegradable municipal waste, such as kitchen and garden wastes and paper, out of landfills in order to reduce emissions of methane (a powerful greenhouse gas). Methane forms when organic materials decompose in the absence of air, a process called anaerobic decomposition. This provides a new reason for city officials to focus on diverting biodegradable municipal waste from landfills. Partly as a result, recycling and organic diversion rates, which had declined to single figure percentages as municipal authorities focused on waste collection, began to rise in cities modernizing their waste systems, in some cases dramatically. Policy measures – including laws with targets for diver- sion from landfill, extended producer responsibility, landfill bans for recyclable waste materials, and recycling and composting goals – pushed the recovery rates up to 50 per cent and beyond, as exemplified by three of the reference cities: Adelaide, San Francisco and Tompkins County. One could argue that history has come 'full circle' now that waste management is begin-

ning to evolve into a mixed system for sustainable resource management. Box 2.1Waste management and climate change Data shows that municipal solid waste management and wastewater contribute about 3 per cent to current global anthropogenic greenhouse gas emissions, about half of which is methane from landfills. One forecast suggests that without mitigation, this could double by 2020 and quadruple by 2050. It is ironic that these forecast increases are largely due to improved disposal in low- and middle-income countries – open dumps decompose partly aerobically and therefore generate less methane than an anaerobic sanitary landfill. Mitigation needs to be a mix of the 'technical fix' approach, such as landfill gas collection and utilization, and upstream measures, particularly reduction, reuse, recycling and composting. Reduction is especially beneficial, as it also reduces the amount of 'embed- ded' carbon used to make the products that are being thrown away as waste. Modernization of solid waste management systems in developed countries For most 'developed'15 countries, the most recent wave of what is termed here as 'modernization' of solid waste management began around the 1970s, when there was a crisis of contamination from waste, either in the city, at the disposal site, or in groundwater or surface water. More important than the crisis itself, the political and media discussion around it has usually provided the immediate stimulus for change. Modernization usually begins with climbing onto the disposal-upgrading ladder – that is, with the phasing out of open dumps. Driver 2 usually results in the closing of town dumps and a plan, often not realized for many years, to develop and operate a 'state-of-the-art' regional landfill. The relatively high costs for building and operating environmental controls means that economies of scale are substantial, which favours large regional landfills, serving a number of cities and towns. Public opposition to new sites, based at least in part on bad experiences with previous uncontrolled sites (not in my backyard, or NIMBY) is a compounding factor, so that the regional landfills tend to be relatively distant from the main population centres. The geographical logistical and institutional regionalization associated with upgrading disposal sets in motion a series of rapid changes in how the waste system functions and how much it costs. The combination of higher technology, more management and longer distance to the new landfill creates a rapid upward spiral in costs for cities and their contractors: •The newly introduced landfill gate fees, based on weighing the waste, are much higher than the costs of local (largely uncontrolled) disposal. •Collection and transport costs are much higher, as the longer distances imply increased time on the road and increased fuel consumption, and possibly the need for local transfer stations. •There are also increased (and often unbudgeted) administration costs involved in organizing 3, 15 or even 50 separate cities and towns together to agree on where the landfill should be, which community should host it, and how the laws, regulations and administration should work. •Political NIMBY opposition to siting intro- duces legal battles that cost the local authority time and money to answer challenges in courtand in the political arena. It is in part to illustrate this process that the reference 'cities' actually include two multi-municipality regions: Adelaide, Australia, is a regional municipality with 19 cities or towns; and Tompkins County, in New York state, is a typical North American unit of government that combines one city, Ithaca, with ten other towns in a relatively rural area. In many developed countries, this upward spiral of costs triggered a search for less expen-sive ways to be modern and environmentally responsible. Some part of the strong interest in recycling and composting came about because, when compared to regional disposal, these activities began to appear to be less expensive, as well as environmentally preferable. During the period of active modernization in the US, for example, recycling goals in many states increased from 15 per cent of total waste to more than 50 per cent in a relatively short period of time at the end of the 1980s Modern municipal recycling, as it has been reintroduced in Europe and North America since the 1970s, depends on households segregating materials at the source. This means that waste system users, the households, need to change their habitual behaviour and to separate their waste into several categories, which they store separately, rather than mixing it all together in one basket, bag or bin. Collecting several source- separated waste streams without greatly increasing collection costs is a similar challenge to the waste collection providers and operators: they also have to change the way in which they think and behave. This has

led, in some instances, to a reduction in collection frequency for the residual waste The solid waste challenge in developing and transitional country cities Experience in low and middle income countries can also be related to the same drivers. The plague epidemic in Surat is one example of a public health crisis that stimulated new initiatives to collect the waste and clean up the city, now known as one of the cleanest in India. The landslide at the Payatas dumpsite in Quezon City, the Philippines in July 2000 killed 200 people – a terrible tragedy – but it also catalysed the political process that resulted in the passage of Republic Act 9003, the Ecological Waste Management Act, one of the most complete and progressive solid waste management laws in Asia. Reawakening interest in resource management has inspired a public– private partnership in Dhaka, Bangladesh, that was one of the first to be issued climate credits. Solid waste management is a major challenge for many cities in developing and transitional countries. The urban areas of Asia were estimated to spend about US$25 billion on solid waste management each year in 1998. Solid waste management represents 3 to 15 per cent of the city budget in our reference cities, with 80 to 90 per cent of that spent on waste collection before modernization. Collection coverage in the reference cities, as in urban areas in general, varies widely, ranging from 25 to 75 per cent in cities where the norm for waste disposal is still open dumping. Why should the authorities choose to invest in a waste system when such investment is likely to raise costs and offer competition for scarce financial resources to other critical municipal systems, such as schools and hospitals? Box 2.2 Plague-like epidemic in Surat, India19 Uncollected solid waste blocking drains caused a major flood, leading to an outbreak of a plaguelike disease in Surat, India, in 1994.The disease caused panic countrywide, and while the citizens blamed the municipality, the public authorities, in turn, blamed the citizens for their lack of civic sense. Over 1000 plague-suspected patients were reported, with the final death toll of 56 people.The city incurred a daily loss of 516 million Indian rupees during the plague period and a total loss amounting to 12 billion rupees.This was a high price to pay for negligence in the area of solid waste management. Alarmed at the situation, the Surat Municipal Corporation undertook a stringent programme of cleaning the city.Within a year after the plague, the level of (daily) solid waste collection increased from 30 to 93 per cent, and 95 per cent of streets are cleaned daily. Market areas, major roads and litter-prone spots are cleaned twice a day. Surat is now identified as one of the cleanest cities in the region. https://thecitywasteproject.files.wordpress.com/2013/03/solid_ waste_management_in_the_worlds-cities.pdf Source:

Solid waste and the Millennium Development Goals (MDGs) • The Millennium Development Goals (MDGs) were ratified by 189 heads of state at the United Nations Millennium Summit in September 2000,with the overall objective of halving world poverty by 2015. • MDGs 1 and 7, on livelihoods and poverty, on the one hand, and on environment, on the other, point to the urgency of inclusive policies in waste management so that the role of the informal waste sector in cleaning up cities and recovering resources is recognized, while working conditions and livelihoods are improved. • Improving the coverage of waste collection services contributes to the healthrelated MDGs 4, 5 and 6, and will reduce both child diseases and mortality. • MDG 8, on global partnerships, is a blue-print for cities to work with private formal and informal actors, on the one hand, and to join with communities in participatory planning and problem solving, on the other. • Partnerships can improve governance, bring about financial sustainability and support proactive policy formulation. Solid waste and the Millennium Development Goals (MDGs) The integrated sustainable waste management (ISWM) framework • When the current modernization process started in developed countries during the 1970s, solid waste management was seen largely as a technical problem with engineering solutions. That changed during the 1980s and 1990s when it became clear that municipalities could not successfully collect and remove waste without active cooperation from the service users. • ISWM identifies three important dimensions that all need to be addressed when developing or changing a solid waste management system – namely, the stake- holders, the elements

and the sustainability aspects. • The examples from Denmark or Japan –which some would regard as world icons of good waste management practice – suggest that a sustainable, affordable waste management system consists of a stable mixture of technologies and institutions, which function flexibly under a clear policy umbrella. • In low and middle-income countries, there is often a variety of formal and informal, public and private systems already operating, so the basis for a stable mixed system is already in place. What most low- and middle-income cities miss is organization – specifically, a clear and functioning institutional framework, a sustainable financial system, and a clear process for pushing the modernization agenda and improving the system's performance The integrated sustainable waste management (ISWM) framework The integrated sustainable waste management (ISWM) framework • The stakeholders – the people or organizations with a 'stake' or interest in solid waste management: who needs to be involved? • The elements – the technical components of a waste management system: what needs to be done? • The aspects which need to be considered as part of a sustainable solution: how to achieve the desired results? • 'Integrated' in ISWM refers to the linkages and interdependency between the various activities (elements), stake-holders and 'points of view' (sustainability aspects). Moreover, it suggests that technical, but also legal, institutional and economiclinkages are necessary to enable the overall system to function Sustainability in solid waste management is possible • 'too good to be true', I • If there was one thing to learn from the Naples, Italy, waste strike in 2007 to 2008, it is that no matter what the politicians do, the solid waste keeps coming. And the public who generate it and the politicians and officials responsible for managing it need to understand what they are doing and be able to make good decisions based on sound local knowledge is probably not true. • For example, large waste-compaction collection vehicles designed to collect lowdensity, high-volume wastes on broad suburban streets built to withstand high axle-loading rates in Europe or North America are unlikely to be suitable for use in a developing country city. There the vehicles have to be smaller, lighter and narrower to allow collecting much denser wastes from narrow streets and transporting it over rutted roads going up and down steep hills – even wellsurfaced main roads tend to be designed for lower axle-loading rates. In many cases, a small truck, a tractor or even a donkey fits local collection needs, while a 20 tonne compactor truck does not. Sustainability in solid waste management is possible • It is this need to keep going, day in and day out, that makes it so critical to shift from the term 'solid waste management' to 'sustainable waste management'. • 'Sustainability' is a long word for 'common sense', and there are some relatively simple ways to improve the performance and sustainability of waste management systems. • ISWM is that all stakeholders need to be engaged and all sustainability aspects need to be addressed. It is the transparent processes of users talking to providers, communities sharing responsibility for planning, and recycling businesses working with cities that make for sustainability. Dare to innovate • At most, low- and middle-income countries have, until now, sought to adapt the models from developed countries to their local circumstances. • Daring to innovate, or to 'think outside the box', helps us to understand, for example, how solid waste is different from many other public utility functions, as the following example shows. • The closest public service to solid waste, in terms of its regularity and complexity, is perhaps the postal service. In a sense, waste management could be viewed as a kind of 'postal system in reverse' – indeed, some researchers have classified waste management as 'reverse logistics'. RECYCLERS AND CLIMATE CHANGE • Material recovery and recycling are for us the best options for managing urban waste. The industrialized countries must reduce their consumption of natural resources, limit the generation of waste, increase recycling and avoid all exports of waste and technologies contributing to climate change. • Recognize the critical and productive role that the recyclers contribute to the mitigation of climate change, and invest resources in programmes for recovery at source that ensure a dignified way of life for all workers and traders from the recycling industry. • Study and remove the support for all projects that divert recyclable waste to incineration or landfilling. • Establish mitigation mechanisms that are directly accessible by recyclers and which are significant in terms of financial and technical support. • Consult the recyclers first in relation to energy from waste generation. •

Support projects and technologies that divert organic waste from landfills by means of composting and methane production, and which should be adopted as options due to the reduction of methane. CONCLUSION • Most people don't care where their waste goes, as long as it is not next to their house. • Whereas an individual misses their post, the individual opting out of a waste management service doesn't notice much 'personal' impact. It is much easier, as well as much more harmful, to burn or dump your own waste than it is to generate your own electricity, or, indeed, to deliver your own letter to your family in a distant village • Waste management isn't as technically complex as energy or housing, but it does have its own set of issues and solutions, and these deserve attention. • So are effective systems to address the 3Rs: reduce, reuse, recycle (i.e. to reduce the quantities of waste generated, and to build on the existing, largely informal sector systems for reuse and recycling.

INTRODUCTION: Because of the difficulties in obtaining comparable information from cities, this Global Report is based on profiling and presenting 20 reference cities. This chapter introduces both the cities and the methodology that has been created to stimulate their participation, and to increase the comparability and accuracy of the data that has been collected. Presenting information in a consistent way helps to understand how things work within and across countries. Solid waste management is fragmented across cities and countries, as well as within them. For this reason, this Global Report profiles a group of reference cities in a consistent way, asking research questions about the nature and sustainability of waste management and recycling in a globalizing world. REFERENCE:SOLID WASTE MANAGEMENT IN THE WORLD'S CITIES-WATER AND SANITATION 2010 PROFILING THE REFERENCE CITIES Global Report 20 reference cities increase the Comparability and accuracy of the data that has been collected. Presenting information in a consistent way helps to understand how things work within and across countries For this reason, this Global Report profiles a group of reference cities in a consistent way WHY: Example: European countries research question: about the nature and sustainability of waste management and recycling in a globalizing world. SELECTING THE REFERENCE CITIES The goal for working with 20 cities was a need for: • a qualitative understanding of what drives the system, how it works and who is involved in it; • hard data and facts from official and reported sources, framed and validated by the visual presentation of a process flow; • information on what works and what doesn't, both in individual cities and across cities. Two sets of criteria were used: Criteria for the mix of cities: • a range of sizes, from mega-city to small regional city; • a range of geographic, climatic, economic and political conditions; • the distribution of cities to include most in low- and middle-income countries, with a significant number in Africa; Criteria for each city: • a city that is willing to participate; • a city willing to invest in preparing the materials and providing information; • a city willing to share both good and not-so-good practices; • someone from or working closely with the city who is willing to take responsibility for collecting data from that city and preparing it in the form desired; • the more close the contacts with the city, the more favourable it is to include it. REFERENCE:SOLID WASTE MANAGEMENT IN THE WORLD'S CITIES-WATER AND SANITATION 2010 The goal for working with 20 cities was a need for: • a qualitative understanding of what drives the system, how it works and who is involved in it; • hard data and facts from official and reported sources, framed and validated by the visual presentation of a process flow; • information on what works and what doesn't, both in individual cities and across cities. SELECTING THE REFERENCE CITIES Two sets of criteria were used: Criteria for the mix of cities: • a range of sizes, from mega-city to small regional city; • a range of geographic, climatic, economic and political conditions; • the distribution of cities to include most in low- and middle-income countries, with a significant number in Africa; at least one from each continent, including a few from high-income countries. CRITERIAS USED: 2 Criteria for each city: • a good illustration of one or more of the main topics and main messages around which the Global Report is structured; • a city that is willing to participate; • a city willing to invest in preparing the materials and providing information; • a city willing to share both good and not-so-good practices; • someone from or working closely with the city who is willing to take

responsibility for collecting data from that city and preparing it in the form desired; • the more close the contacts with the city, the more The 20 reference cities used in the book provide a reasonable cross-section across the world, but meeting all possible selection criteria is challenging. It is hoped that similar city profiles will be prepared and published in the future; priorities for inclusion would include cities from the former Soviet Union/Newly Independent States; Middle East; English-speaking West Africa; Portuguese-speaking Africa and an island city state.

How is it possible to research and understand 20 cities in a short period of time? Some basic instruments have been derived from the integrated sustainable waste management (ISWM) framework, with a focus on three system elements and three governance aspects, and include: 1. using a process flow approach to understanding the entire waste and recycling system through the construction of a process flow diagram (PFD); 2. developing and requesting unusual data points and indicators as a way of extending the boundaries of what can be understood and compared; 3. designating a person who has worked in the city and knows it well, named hereafter the 'city profiler' 1. process flow diagram (PFD) gives a fast picture of what is happening to which streams; • the whole system is included in the analysis; • where the system boundaries are and provides a structure for analysing the materials that 'escape' from the system; • shows where the materials actually end up; • provides a check on data provided in other ways • allows for and, indeed, facilitates understanding linkages between formal and informal activities, actors and steps in the chain of removal, processing, valorization or disposal; • the degree of private-sector participation in the system and in the management of different materials; • is a reliable way of estimating recovery rates for specific materials and mixed streams; • allows for comparison of costs and efficiencies between different operations and for the system as a whole; • shows the degree of parallelism and mixing in the system. Information and indicators A short set of indicators was, secondly, prepared based on the six ''themes' of ' good practice in ISWM components that form the focus of this report, as follows. Three drivers and physical elements: 1 Public health/collection. 2 Environment/disposal. 3 Resource management. Three ISWM governance aspects, which include: 1 Inclusivity. 2 Financial sustainability. 3 Sound institutions and proactive policies. These indicators are useful for analyzing how processes work within a city and comparing across cities. The point is not so much to see how one city 'scores', but how things cluster and what this tells about the city. One of these new indicators was inspired by the experience of Delhi/New Delhi, where the profiler and Chintan-Environmental, the host NGO, were astounded to find out how challenging it was for the city officials to find or provide information. This led to the creation of a relatively new governance indicator: the age of the most recent reports that are available. In the comparative tables distributed throughout this Global Report, as many cities as possible will be included in the comparison based on the availability of information per city. In cases where information is not reported, the abbreviation NR will be marked, and in cases where information is not available, the abbreviation NA is used. The role of city profilers Third, the individuals who described the cities for the book (the 'city profilers') are mentioned; these city profilers collected examples, stories, photos, newspaper articles and other qualitative information. Together with the profilers, the co authors and editors of the book used their collective experience to really understand the 'story' of solid waste in each city, how the drivers have influenced solid waste, and how to understand both successes and problems. Some examples of 'stories' include the following: • Cities with good collection at the submunicipal level, such as Bamako or Nairobi or Managua, may have distant, limited or no controlled disposal simply because there is no one at the city council level who 'owns' the problem or is committed to proactively seeking a solution. • Or consider the paradox of Curepipe, Adelaide and Rotterdam: too much moderately priced disposal reduces incentives for both users and providers to work on source separation and recovery of recyclables and organic waste – even when there is a policy commitment. The result is missed opportunities and disappointing recycling performance. Other ways of understanding the cities include comparative tables, photos, diagrams and stories; these have come from the city profilers;

from their sources (both in terms of reports and in terms of talking to people) in the cities; and from the collective professional memory of all the writers and teams working on the Global Report. The sum of all these parts is designed to give a three-dimensional insight into the cities that builds understanding about ISWM in specific places, and also in its totality

INFORMATION QUALITY If knowledge is power, than a city without knowledge of its solid waste system may lack the power to make positive changes. Solid waste information is subject to a number of widely encountered structural weaknesses. In many cities, information on solid waste is: • old – more than 10 years' old and, in some cases, more than 15, while changes in the composition of the waste stream, population and behaviour are continuously occurring; • orphaned – neither owned nor recognized by the city itself, particularly in low- and middle-income countries, where a donor, or a state, provincial or national government paid for the study or financed the consultant, and did not ensure that the information was useful for the city; or where there is no central archiving system in the city; • secret – considered to be secret or proprietary because of the involvement of private-sector actors or investors; • estimated – estimated based on national or regional figures, without verification in field assessments; • political – highly politicized and subject to distortions in support of the policy ambitions of particular stakeholders; • not permanent – because it related only to a specific period of a government administration and experiences from previous administration are seen as 'useless'; • missing – missing or incomplete because there is no party willing to invest in gathering accurate information on such a dirty subject; and/or • inaccessible – because it might not be written in the language of the municipality, but rather in the language of the consultant hired by the donor. On the other hand, city governments or solid waste agencies that consider waste to be a priority have the tendency to invest in monitoring and documentation of waste information and reap the benefit of good data. And cities that have a strong resource management driver and are seeking to achieve high recovery rates are often willing to invest more in detailed waste characterization studies, so that they really understand what can be recovered. As a result, quality of information may serve as an indicator of commitment. CITY INDICATORS • Each city has a series of indicators that are representative of different aspects of a city's solid waste system. Behind these indicators are the overarching 'drivers' for the modernization of the solid waste management system, which include improving public health, reducing impacts to the environment, and increasing resource recovery through minimizing waste generation combined with increasing materials recycling. These three drivers should be considered linked; addressing impacts upon the environment necessarily includes addressing potential impacts upon human health. Similarly, reducing waste generation and subsequent disposal through waste prevention, reuse and recycling has quantifiable benefits to both human health and the environment. • An integrated and sustainable waste management approach to solid waste necessitates addressing these three elements; but this is done within the context of government institutions. The modernization of the solid waste management system often sees establishment of new policies, regulations and possible restructuring of management and administration to better address the minimization of public health and environmental impacts while maximizing the recovery of resources from the waste stream. • An 'indicator' suggests that a data set has been chosen to provide an indication of how a city has addressed one of the aforementioned drivers. The chosen indicators in Table 3.2 should not be considered as the only lens through which one would assess the movement towards a modernized solid waste management system. Description of each indicator • Collection/sweeping coverage: percentage of the city that receives a regular service of waste collection and street sweeping. The driver is public health, involved with keeping garbage and the associated vectors from waste accumulating within the city. • Controlled disposal:percentage of the waste that ends up in a disposal facility with basic controls.The driver could be considered both public health, especially with labor associated with disposal sites, as well as environmental protection of soil, water and air resources.

SAN FRANCISCO California, West Coast, US, North America • The city and county of San Francisco, California, is the financial and administrative capital of the western US and a popular international centre for tourism, shipping, commerce and manufacturing. • The initiator of the United Nations Environment Programme (UNEP) Urban Environmental Accords, San Francisco, is a national and international environmental leader. • This willingness to take the lead is what drives San Francisco's environmental programme. Collection of waste in San Francisco • The Fantastic 3 Program, initiated in 1999 and completed citywide in 2003, uses black, blue and green 240-litre wheeled carts. • Generators segregate materials and split chamber trucks simultaneously pick up trash and recyclables. • streets are swept mechanically at least once per week; several high-traffic areas are swept daily. disposal • Since it does not have a landfill, San Francisco's discards are hauled 85km to Waste Management's Altamont Landfill. • Garbage rates have been set to strongly encourage recycling or composting. • In the commercial sector they are discounted by up to 75 per cent off the cost of trash. • In the residential sector, recycling and composting collection are provided at no additional cost. • This 'pay-as-you-throw' system underpins San Francisco's diversion strategy and drives environmental programmes. Resource management • The average San Franciscan generates 1.7kg of waste per day, of which 72 per cent is recycled. • Three-quarters, 75 per cent, of the remainder could be diverted by existing programmes, and once this is realized, the city will achieve more than 90 per cent diversion. Special features • 'Zero waste or darn close'. The zero waste challenge is reflected in solid waste system support for reducing consumption, maximizing diversion and encouraging reuse, repair and green purchasing. • banning troublesome goods such as plastic bags and superfluous packaging, and promoting alternatives such as recyclable or compostable take-out food packaging and reusable transport packaging. • Most of these actions require ongoing outreach at homes, schools, businesses and events. • In some cases, mandates and ordinances are required, such as mandatory segregation of recyclables and organics, and construction and demolition debris. • One next major step includes supporting the passage of state wide legislation that holds manufacturers, businesses and individuals accountable for the environmental impact of the products that they produce and use. ROTTERDAM South Holland, The Netherlands, Europe • The main driver has been the growing environmental awareness among the population and the increasing tendency to preserve the resource values of waste. • This awareness has resulted in an aggressive Dutch national policy framework that works to eliminate landfilling and maximize materials and energy recovery. • Rotterdam's compliance is selective: the city chooses to maximize energy recovery. Collection • ROTEB, the municipal waste management department, is run as a public company although its budget comes from the municipality. • Waste collection operates according to a weekly routine, applying one (plastic bag, 240 litre container), two (plastic bag, 1100 litre container) or three (3m3, 4m3 and 5m3 underground containers) collection services per week. Disposal • The high water table in The Netherlands and its high degree of urbanization have pushed the country to opt for minimizing landfilling and optimizing recycling, composting and incineration. Disposal: • The result is a dense network of processing and disposal facilities owned by both private and public companies, and Rotterdam has more than its share of high-performance disposal facilities. Resource management • During the 1980s The Netherlands was one of the most progressive and recycling-oriented countries in Europe, together with Germany and Denmark. • The recovery strategy is based on research and analysis of the environmental footprint of 29 classes of products and materials. • National policy goals regarding recycling and waste minimization are established in the recently updated National Waste Management Plan 2009– 2021.

WASTE COLLECTION: PROTECTING PUBLIC HEALTH Basic issues Together with sanitation as the safe management of human excreta, effective removal and treatment of solid waste is one of the most vital urban environmental services. Waste collection represents both an essential utility function, together with electricity, gas and clean water, and a necessary part of urban infrastructure and services, alongside housing and transport, education and healthcare. In cities, poor solid waste management has a direct impact upon health, length of life and the urban environment. This matters

and it is the basis for the idea that removing solid waste from urban centres is an essential function of the city authorities. Ever since the middle of the 19th century, when infectious diseases were linked for the first time to poor sanitation and uncollected solid waste, municipalities have therefore been responsible for providing solid waste collection services to their citizens. When solid waste is not removed, it ends up somewhere. That 'somewhere' is open spaces, backyards, public parks, alongside roads or pathways, and in nearby rivers or lakes. Waste is burned in a barrel or in a heap. Children, especially those living in slums, play in it and with it. Poor waste management usually affects poor people more than their richer neighbours. Often the city centre receives a door-to-door collection several times per week and the periurban or slum areas rely on containers that are emptied so seldom that the area around them becomes an informal dumpsite, attracting insects, rats, dogs and grazing animals, and, always, more waste. Maharashtra in India banned the manufacture, sale and use of plastic bags in 2005; unfortunately, poor enforcement means that the ban has so far been ineffective. In West Africa, floods are being blamed on the small plastic pouches for drinking water. Uncollected waste has economic, social and technical costs for a city. A dirty and unhealthy city will make it difficult to attract businesses. In Tangier, Morocco, pollution of beaches by solid wastes was cited during the late 1990s as the leading cause of tourism decline that cost hotels in the area US$23 million per year in lost revenues.4 In Costa Rica, the electric utility company has had so many problems with plastic litter clogging the turbines of their hydroelectric plants that they are financing plastics recycling in the catchment area behind their dams. Insights from the reference cities and global good practice in waste collection Effective waste collection is all about the city authorities understanding their citizens and their city, and making a focused and sustained effort to mobilize the human and financial resources. Many parts of the system need to work together to remove waste, serve households and keep the city clean. The authors of this Third Global Report generally agree with their colleagues worldwide that getting collection under control is the first step in climbing onto the modernization ladder. The reference cities show a wide variety of experience and give some new insights into how to do this efficiently, fairly and effectively. This section explores this under three headings, which echo the experiences of the cities and what they are proud of doing well: • keeping the cities clean; • improving cost effectiveness of the services; • creating effective channels of communication between users and providers. The wastes are collected by single-axle (4 2) compactor trucks that average 8000kg per load, with a gross vehicle weight of 17,000kg (although this exceeds the legal gross load limit of 15,000kg for 4 2 trucks in the country concerned) and are transported directly to the landfill. This is a very slow system as the trucks must travel long distances (average 6km 2 = 12km return journey) within the city as well as long distances (40km 2 = 80km return journey) to the landfill. Collection must take place at times when the city is free of traffic, taking 2.5 hours

INVESTMENT IN DEVELOPING COUNTRIES: • Achieving financial sustainability is still a work in progress in all of the developing country cities. Financing and investment needs are serious in waste management, especially for middle- and small-sized cities and in low-income countries. • The investment needs are estimated based on 'internationally recognizable' standards and environmental protection solutions are not affordable for the governments and their people. • As a result present strategies, action plans and investment projects of developing cities cannot afford or sometimes, even when it does, the result is a landfill site that waits for the landfill to be built, or an investment in a processing facility that the city cannot afford to operate. • The organizations which could provide the necessary finances are generally just not available. • Solid waste budgets largely come from national governments, but they do not have the funds to invest in new infrastructure. This leaves the international financial institutions and private investors, who bring a range of conditions where most of if require 'international' standards on which they are not allowed to compromise or affordable for the recipient. ISSUES FACED WHILE RUNNING MODERN LANDFILLS: • The research in this Global Report confirms that the operational cost for primary collection is generally affordable, even

in poor communities; secondary collection already raises issues of affordability and willingness to pay in many cities. • Modern landfills to donor standards is often beyond the capacity of municipal governments: the Ghorahi site is an exception which is funded by local sources that makes use of a natural clay 'liner', which may or may not be acceptable to some donors • If the donor capital is a grant, two issues arise, 1. ISSUE 1 - The first is the capacity of the city to operate and maintain the equipment or facility as it was designed, whether a collection vehicle, a landfill site or a treatment plant – the world is littered with examples of donated compactor trucks or incinerators which don't work, and landfill sites which have reverted to open dumps because the city cannot afford to run them or to repair them. 2. ISSUE 2 - How to replace the vehicle or the landfill site at the end of its life. Grant funding may be helpful in the right circumstances and if the vehicle or facility is appropriate, which is not a long-term solution. • If the investment is a loan, then the issue is not just about operational cost but also about debt repayment. A city can only afford to borrow a certain amount if it is to meet the repayments, so solid waste must compete with other funding priorities, such as health and education. • But individual cities and countries cannot solve this on their own a sustainable local solution must be acceptable, appropriate and affordable in the local circumstances. • However, neither International Financial Institutions, nor National Governance Structures are geared to this 'pickand-mix' approach. IFIs and their governing boards need to look again at their policies, particularly at their insistence on 'international standards' as a condition for financing. • It has taken 40 years of the current phase of solid waste modernization for developed countries to achieve these standards across the board, so it seems unreasonable to insist that the same standards form part of the next step in every developing country as a condition of providing financial assistance. MAKING INTEGRATED SUSTAINABLE WASTE MANAGEMENT SUSTAINABLE… • Identifying and naming problems, meetings with a range of stakeholders, finding solutions that are appropriate to specific local situation in order to set off from where you are and where you want to be. • If in a early stage of this journey of modernization of solid waste management system, then it is important to identify simple, appropriate and affordable solutions that can be implemented progressively which can be afforded. • ISWM approach is to focus on building your existing recycling rates and taking measures to bring waste growth under control. This is particularly important, as every tonne of waste reduced, reused or recycled is a tonne of waste for which the city does not have to pay for its transport and safe disposal. • The best strategy is to understand and build upon the strengths of the city – to identify, capitalize on, nurture and improve the indigenous processes that are already working well.

PUTTING INTEGRATED SUSTAINABLE WASTE MANAGEMENT INTO PRACTICE υ All the key principles of solid waste management are listed above. υ ISWM – Case studies on Delhi, Banglore, Ghohari. υ It involves both the users and service Providers. Building Recycling Rates: υ Solid Waste modernization happened – 1990's & 2000's. υ Every countries started to set recycling goals to achieve to work on high recycling rates to divert the waste from landfills to reduce the cost. υ In many countries, recycling had fallen & they had gone to new systems like, Landfill taxes, recycling targets, extended producer responsibility. υ It makes less cost. υ Comparision of recycling rates with modern western systems. υ They had mentioned the % of recycling rates with the numeric data. υ The waste from the streets & dumps along the built-up area should be recycled or else the rate of recycling would be dramatically increased. υ Even in Delhi had contributed to 16% of recycling rate. A focus on waste reduction: υ Before waste recycling , at first we have to redue the waste being produced - 3R. υ Zero waste in South Australia provide a good global practice on 3 R concepts. υ In US & Rotterdam, reuse & the organization of recycling process is very important process. υ The kitchen wastes are recycled as livestock feeding . υ Even in Srilanka and Bulgeria, a formal recycling Programs happened. υ Cencus shows that for past 40 years, good policies of solid waste management increased. υ Waste quantities increased due to the population. An ISWM approach is likely to come at the problem from three directions at the same time: υ 1. from the 'bottom', to get onto the hierarchy

in the first place by phasing out open dumps; υ 2. from the ‘middle’, ensuring that wastes are increasingly diverted from disposal to reuse, recycling, organics valorization and composting; and υ 3. from the ‘top’, to reduce waste at source and to bring waste growth under control so that a city can make real progress rather than ‘running hard simply to stand still’. Use all available sources of finance: υ CDM (Clean Development Mechanism) to improve Waste management. υ At early 1990’s, Landfills sites are developed by the donor giving only capital cost but it was failed due to the lack of operational cost. υ A amount is given annually to a city for the mainatenence of landfills to collect the gas out of waste which can be used as electricity. υ Dhaka – obtain the carbon credits for recycling. υ Extended Producer Responsibility (EPR) . υ In Europe, has been successful because they had managed the retailers and producers for waste seperations. υ The best example is Netherlands – Middle income country. υ The other innovative Examples- Youth NGO with Zabbleen community of Informal Waste collections. Conclusions : υ The approach is creative & critical. υ Built up the cities in our own way. υ To all involve all the stakeholders. υ Adapt the solutions that will work in our particular situation.

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT – IV – Sustainable Waste Management – SARA5332

IV. UNIT 4

Waste as a Resource

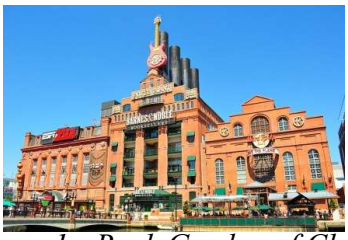
Architectural reuse – waste prevention, pre building, building, post building stages, construction and demolition recycling -Conservation of natural and building resources – types of wastes – elimination of waste and minimize of pollution – various decomposing methods - Environmental monitoring and testing during construction – design facility within social and environmental thresholds

Adaptive reuse

- refers to the process of reusing an old site or building for a purpose other than which it was built or designed for.

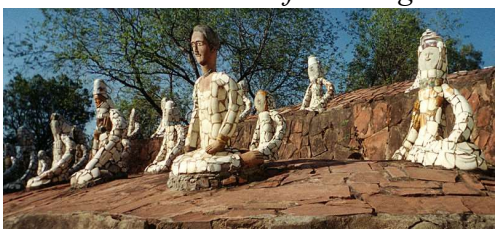
Factors affecting adaptive reuse

- **societal value** of a given site
- **potential** for the reuse of a particular site;
- **historical** importance of the site - terms of both the physicality of the street-scape and the area
- **natural** ecological conditions of the site



Pratt Street Power Plant in Baltimore, Maryland, United States, converted into retail, restaurants, and offices.

Figure 1 - Rock Garden of Chandigarh



it is spread over an area of forty-acres,
it is completely built of industrial & home waste and thrown-away items.
man-made interlinked waterfalls and many other sculptures that have been made of scrap & other kinds of wastes (bottles, glasses, bangles, tiles, ceramic pots, sinks, electrical waste, etc.) which are placed in walledpaths), complex of interlinked courtyards, each filled with hundreds of pottery-covered concrete sculptures of dancers, musicians, and animals

"Waste - a resource in the wrong place"
-- An old Chinese proverb

Waste – Noun Vs Verb

waste *v.*	**waste** *n.*
1. to **use**, consume, spend, or expend thoughtlessly or carelessly	1. a place, region, or land that is **uninhabited or uncultivated**
2. to **cause** to lose energy, strength, or vigor; exhaust, tire, or enfeeble	2. a **devasted or destroyed** region, town, or building; a ruin
3. to **fail** to take advantage of or use for profit	3. a **useless or worthless** by-product, as from a manufacturing process
4. **to destroy** completely	4. garbage; trash

Waste prevention ……right form	
Planning Process	Site selection and planning Budget planning Capital planning Programme planning
Design Process	Client awareness and goal setting - Green vision, project goals & green design criteria Team development Well-integrated design Resource management Performance goals
Operation & Maintenance	Commissioning of building systems Building operation Maintenance practices Renovation & demolition

Table 1 – Waste classification

Construction Waste Management

- Responsible management of waste is an essential aspect of sustainable building.
- sustainable management of resources - **reduction, recycling, and reuse** of wastes
- In this context, managing waste means
  - eliminating waste where possible;
  - minimizing waste where feasible; and

– reusing materials which might otherwise become waste.

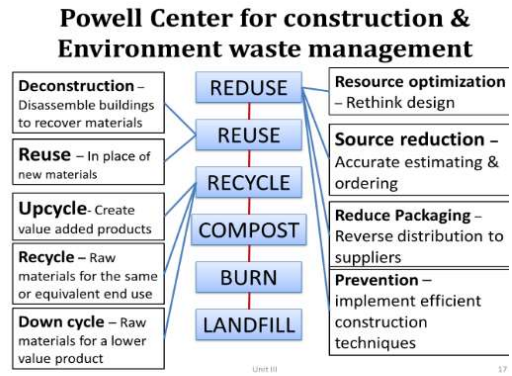
Effective management of building-related waste

- Waste prevention
- Recycling construction and demolition materials
- Architectural reuse (include adaptive reuse, conservative disassembly, and reusing salvaged materials)
- Design for material recovery (durability, disassembly, adaptive reuse)

Figure 2 – Measures

Waste prevention is about the way in which the **products and services** we all rely on are

- designed
- Made
- bought
- sold
- Used
- Consumed
- disposed



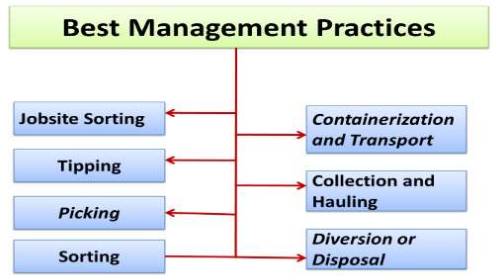


Figure 3- Management Practices

Jobsite Sorting	• efficient identification and sorting of materials is an important factor • Materials may be sorted into a number of containers provided by service companies that specialize in management of specific types of waste at the jobsite. • least number of containers is desirable both to keep container volumes high to reduce transportation trips and costs
Collection and Hauling	Containers containing construction and demolition waste are collected and transported to diversion facilities via truck.
Tipping	Identification of loads on arrival at construction and demolition debris diversion facilities is an important step in ensuring materials are appropriately handled.
Picking	Materials such as steel reinforcing bar, carpeting, large pieces of wood, concrete and materials with dimensions greater than 3 feet are usually picked before the sorting process can begin in earnest.
Sorting	involves loading materials onto an inclined metal belt—a chainbelt—and passed across a manual sortline consisting of a flexible rubber belt and integral sort stations providing a place for several workers to stand, usually opposite from one another down the length of the belt. Materials are identified, grabbed, and deposited in vertical openings at each sort station.
Containerization and Transport	Picked and sorted materials are deposited by means of equipment and manual labor into industrial containers of various types. Heavy interstate trucks are an important part of the transportation system. Containers of all types are destined for transport locally, regionally, nationally and internationally.
Diversion or Disposal	incorporation in new products as recycled material, or are processed for reuse. Materials destined for disposal in landfills include refuse, materials contaminated with waste or which have been ruined, and materials for which markets do not exist.

Table 2 – Classification

Figure 1 - A simplistic perspective on the building supply chain

Construction & demolition recycling

- Building materials account for about **half of all materials used** and about **half the solid waste generated** worldwide.
- They have an environmental impact at every step of the building process—
  - extraction of raw materials
  - processing
  - manufacturing
  - transportation
  - construction
  - disposal at the end of a building's useful life.

construction and demolition waste

- Construction and demolition (C&D) waste is a general term for a diverse range of materials that, when segregated, can include high-value materials and resources for new construction.
- Construction and demolition waste is generated whenever any construction/demolition activity takes place, such as, building roads, bridges, fly over, subway etc.
- consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics **etc.**

Advantages and Disadvantages of Source Separation vs Commingled Recycling		
Recycling Method	**Advantages**	**Disadvantages**
Source Separation - separating different recyclable materials at the job site	• Higher recycling rates • Lower recycling costs; revenues paid for some materials • Often a cleaner, safer work site	• Multiple containers on site • Workers must separate materials for recycling • More complex logistics • Multiple markets; more

		information to manage
Commingled Recycling-means placing all recyclable materials into a single container, which is then transported to a processing facility, where different materials are separated by hand or by automated equipment.	Only one or two containers on site • No need for workers to separate materials for recycling • Easier logistics • One market; less information to manage	• Lower recycling rates • Higher recycling costs

Table 3 - Advantages and Disadvantages of Source Separation vs Commingled Recycling

Source separation

- is more complex because workers must separate waste materials before they throw them away
- there are more containers on site
- there are more markets and haulers to work with and keep track of.

source separation is economically more advantageous than commingled recycling

- Source separation produces materials that are ready to go directly to market;
- there is no need to pay a processor to sort materials.
- Source separated materials are generally of higher quality, with fewer contaminants
  - They're worth more in recycling markets

A few additional rules make source separation work smoothly

- Keep as few containers as possible on site at any time.
- Match containers to the material.
- Place containers close to work locations

WHAT TO LOOK FOR IN A HAULER FOR RECYCLED MATERIALS

Flexibility	• **different types of containers and vehicles for different recycled materials?** • **Number of trucks and containers** • **Meet the client's requirements** • **Response time**
Market Relationships	Are they tied to only one or a few markets, or do they work with many markets? Will they work with markets that you identify?

Reliability	• Check with other people they've worked with. Do they show up on time, and call if there are going to be any problems? • Do they have backup if a truck or another piece of equipment breaks down?
Location	Where are they located compared to the job site and to markets? Longer hauls mean more cost and more possibilities for things to go wrong?
Cost	What is their price structure? Be sure to comparison shop, because proposed rates can vary by 30% or 40% for the same haul.
Safety	Ask for documentation of safety and driving violations

Table 4 - What to Look For In A Hauler For Recycled Materials

WHAT TO LOOK FOR IN A MARKET FOR A RECYCLED MATERIAL

Process and End Products	**Be sure you're comfortable that their recycling process and products are in line with your own recycling and environmental goals.**
Materials	How many do they handle? All other things being equal, you'd prefer to deal with fewer markets. Be sure to shop and compare
Hauling	Will they haul as well as provide a market?
Pricing	How do they compare to other markets for the same materials? Do they return revenues for materials like metals? Are prices tied to published indexes?
Financial History	Check credit references and other sources of information to verify stability
Tracking/Reporting	certificates of recycling, or other documentation you need to confirm recycling quantities, rates, and ultimate end uses.
Safety and Environmental Record	Do an on-site audit. Look for safety and environmental issues (availability of safety equipment, general neatness, attitudes toward safety/environment, etc.)
Insurance	Confirm that insurance is in place, adequate, and paid up.

Table 5 - What To Look For In A Hauler For Recycled Materials

Building Materials – Major components

- Cement concrete
- Bricks
- Cement plaster
- Steel (from RCC, door/window frames, roofing support, railings of staircase etc.)
- Rubble
- Stone (marble, granite, sand stone)
- Timber/wood (especially demolition of old buildings)

Building Materials – Minor components

- Conduits (iron, plastic)
- Pipes (GI, iron, plastic)
- Electrical fixtures (copper/aluminium wiring, wooden baton
- bakelite/plastic switches, wire insulation)
- Panels (wooden, laminated)
- Others (glazed tiles, glass panes)

STORAGE OF CONSTRUCTION AND DEMOLITION WASTE

- should be stored within the site
- keep the waste segregated into different heaps , further gradation and reuse is facilitated
- Segregation – reused in the site, sold / refilled
- Local body should provide required containers
- Public projects –special provision for storage of wastes

COLLECTION AND TRANSPORTATION

- Skipp lifters, trailers, tractors (manual loading and unloading – last option)
- For small generators of construction debris, e.g., petty repair/maintenance job, there may be two options –
  (i) specific places for such dumping by the local body
  (ii) removal on payment basis.

RECYCLING AND REUSE

- **Reuse (at site)** of bricks, stone slabs, timber, conduits, piping railings etc. to the extent possible and depending upon their condition.
- **Sale / auction of material** which can not be used at the site due to design constraint or change in design.
- Plastics, broken glass, scrap metal etc. can be used by **recycling industries**.
- Rubble, brick bats, broken plaster/concrete pieces etc. can be used for **building activity**, such as, leveling, under coat of lanes where the traffic does not constitute of heavy moving loads.
- Larger unusable pieces can be sent **for filling up low-lying areas**.
- Fine material, such as, sand, dust etc. can be used as cover material over **sanitary landfill**.

INSTITUTIONAL AND REGULATORY ASPECTS – FOUR OPTIONS

- The total activity may be **contracted** out.
- Only **vehicles** may be **leased** out by the civic body to the private contractor for transport of debris with his own labour, i.e., labour contract.
- The vehicles may be **hired** by the local body from private sources for transport of debris with municipal labour.
- The total activity may be carried out by the LOCAL BODY.

Material	Description and Sources	Markets	Limitations on Recycling
Brick	Largely from demolition and renovation. Limited waste from new construction.	High-value re-use markets for some brick. Used in aggregate production.	Few limitations.
Concrete, Formed	Largely from demolition and renovation. Limited waste from new construction.	Mixed aggregate markets with brick and block. Used in aggregate production.	Concrete w/ rebar typically must be separated from brick, block, and concrete w/out rebar.
Concrete Block	Largely from demolition and renovation. Limited waste from new construction.	Mixed aggregate markets with brick and concrete.	Few limitations.
Metals, Ferrous	Structural and framing steel from demolition. Framing scrap from new construction and renovation.	Scrap markets; used in production of new steel.	Few limitations.
Metals, NonFerrous	Aluminum, copper, brass and alloys from electric, plumbing, and HVAC. Often significant scrap in new construction.	Scrap markets. Highest value if separated by metal at point of generation. Can be mixed and marketed with ferrous metals.	Few limitations.
Wood, Engineered	Significant quantities from new construction and renovation as well as demolition.	Some re-use value through deconstruction. Most is recycled as boiler fuel.	Generally few limitations.
Gypsum Wallboard	Clean scrap from renovation and new construction.	Currently no markets for demolition wallboard.	Clean scrap from new installation only, without tape, nails, screws, corner bead.
Ceiling Tiles	Largely from demolition and renovation.	Recyclable with considerable quantity	Subjected to test before recycling

	Generally limited waste from new construction.		
Roofing, Metal	Large quantities from demolition and renovation.	Scrap markets.	Few limitations.
Carpet	Large quantities from replacement, demolition, renovation. Significant scrap from new installation.	Carpet is taken apart into multiple materials which are then recycled separately	Carpet must be dry and mold free. Cost is typically very high.
Mixed Debris	Large quantities from demolition and renovation. Small to large quantities from new construction, depending on feasibility of source separation	Sorted mechanically and/or by hand into constituents, typically wood, metal, aggregate, and residual.	Recycling rates typically less than source separated, and costs are typically higher.

Table 5 - Institutional and Regulatory Aspects – Four Options