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Industrial and urban waste management in Punjab

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1 Background

As per CPCB annual report, the state of Punjab generated around 1266 tonnes per day (TPD) of MSW in 1999-2000 which has increased to around 2793 TPD in 2011. (CPCB, 2012). Almost all the MSW in the state is disposed in unscientific disposal facilities. Also as per the CPCB hazardous waste inventory report of 2009, the state had 3023 hazardous waste generating units and it generated 180,000 tonnes of hazardous waste (13601 tonnes landfillable, 14831 tonnes incinerable and 89481 tonnes recyclable) on an annual basis. As per CPCB report on sewage generation and treatment, sewage generation in class I[1] cities was 1528 MLD but the treatment capacity was only 411 MLD. Similarly, in class II[2] towns, the generation rate was 157.4 MLD and the treatment capacity was only 42.8 MLD.

The population of Punjab is expected to rise in the years to come and the waste generation in any city is a factor of population and the socio – economic behaviour of the community. Total Municipal Solid Waste generated in Punjab in 2011 was 2793.5 T/day (CPCB, 2012). The amount of waste generated per capita is estimated to increase at the rate of 1-1.33% annually. (Pappu et a., 2007). Using TERI estimates for the urban population projections in the year 2011, 2021, 2031 and 2041, the total amount of waste generated in the Punjab can be calculated, as shown in the Table 1 below.

Table 1: Estimated waste generation on Punjab

	Punjab		
	Per capita waste generated(Kg/day)	**Urban Population (x1000)**	**Waste generated (T/day)**
2011	0.276	10119.61	**2793.5**
2021	0.315	12070.35	**3802.6**
2031	0.359	13885.88	**4992.5**
2041	0.410	15516.66	**6366.8**

Source: Population projection by Scenario B, Population Forecast of India

The daily waste generated in the state of Punjab is expected to rise by almost 128% by 2041. Even today the state is struggling with waste management and in the coming years the quantum of waste generated is only expected to increase, this poses a crisis to the urban local bodies.

[1] Class I: Population above 100,000
[2] Class II: Population 50,000-99,999

Historically, the Urban Local Bodies in Punjab have worked independently without much coordination resulting in little or no treatment of the waste collected and unscientific disposal of waste at dumpsites. This led to resistance from public and the state government was eventually forced to come up with a waste management plan.

2 Institutional Framework

2.1 State policy framework

The National Urban Sanitation Policy of 2008 stipulates that the municipal waste management strategies must be reflected at the state level in the State Sanitation Strategy (SSS) and the City Sanitation Plan (CSP). This will ensure that the regional variation in the amount and type of Municipal Solid Waste is duly acknowledged and appropriate steps are taken to handle it. Also, issues like land acquisitions for waste management purposes and engagement with local stake holders can be solved more efficiently if the decision makers have region specific know-how and understanding.

According to the draft MSW Rules, 2015, the following are the responsibilities of state governments:

- Enforcement of these rules in cities.
- Forming guidelines for the ULBs to manage municipal solid waste.
- Reporting on the Service Level Benchmarks for solid waste management service by ULBs to MoUD.
- Allocating land to private players for construction of solid waste management facilities.
- Facilitate a regional sanitary landfill facility for a group of cities and to ensure professional management of such facility.
- Provide guidance to cities in managing grants for SWM activities.

A Solid Waste Management Cell (SWM Cell) must be constituted by the state government within the Department of Urban Development at the state level. Besides developing the state level solid waste management policies, the cell must also act as a nodal agency to all the ULBs in the state, collect data from them on annual basis and then forward that data to the respective SPCBs. (CPHEEO, 2014)

At the policy level, Punjab State government has acknowledged the importance of efficient solid waste management in sustainable development. This is clear from the steps taken by the government to manage the waste from the state like the 'Punjab State Action Plan for Climate Change', aims at realizing 20% of 100MW energy potential from waste by 2022. Apart from the above mentioned steps some other initiatives taken by the government include enactment of Punjab Plastics Carry Bags (Manufacture, Usage and Disposal) Act, maintenance of landfill site for municipal solid waste, planning of the SWM project for Ludhiana cluster under JNNURM and preparation of DPR by Punjab Pollution Control Board (PPCB) for towns of Mandi Gobindgarh and Kartarpur. (Department of Science, 2012)

PPCB aims at facilitating reduction of waste at the source itself. To achieve this, following measures have been taken by them:

- Encourage the establishment of Common effluent treatment plants (CETPs) to reduce the point sources of industrial pollution.
- All small scale electroplating industries of Ludhiana have become members of CETP and the treated effluent from these CETPs is being used by other industries as raw material.
- Electroplating industries in Jalandhar are following the same trend. The board has directed industries to join the CETP. The treated units from the CETPs shall be circulated to the nearby industries.
- A 'zero liquid discharge' achieved by all the large and medium units in Ludhiana.
- The quantum of wastewater generation is reduced considerably in dyeing units by the installation of new machines, technology with less liquor ratio and better absorbing dyes.
- In the Pharmaceutical sector, the condensates generated from waste water are being recycled back with the help of latest technologies like Multiple Effect Evaporator (MEE).
- All the distillery units have been directed to adopt zero discharge policy by the Board. Four units have already complied.
- Technologies for reusing effluents within the industry itself have been adopted by large units like NFL, Nangal, PACL, Nangal etc.
- The State Govt. has selected 45 towns located on/near the banks of the three major rivers Satluj, Bead and Ghaggar for the installation of Sewage Treatments Plants so as to stop the discharge of untreated effluent into these rivers. (Department of Science, 2012)

2.2 Framework for Implementation

The responsibility of implementation of the municipal waste management lies on the urban local bodies. This includes all aspects of waste management – collection, transportation, storage, processing and disposal. There are 143 ULBs and 4 Municipal Corporations – Amritsar, Ludhiana, Jalandhar and Patiala, in Punjab. ULBs also have the power to frame by-laws and charge user charges in order to manage the waste.

In 2010 court cases were filed against the State of Punjab due to unscientific dumping of Municipal Solid Waste. These included: Pathankot Welfare Society v/s State of Punjab, Rajinder Singh v/s State of Punjab and Capt. Mall Singh v/s State of Punjab. In response to this the court directed the Punjab pollution control board (PPCB) to prepare a list of existing garbage treatment plants and future requirements. It was realized that the new treatment plants could not be established in a day and PPCB was also asked to come up with viable and executable options to safely dispose waste till the government comes up with a plan to manage waste.

In response to this, PPCB came up with a 10 point solution also known as common action plan (CAP) as an immediate answer to the unsanitary dumping of municipal solid waste. The details of the CAP are as follows:

1. First of all, waste in each dumping site shall be scrapped and piled up in a corner. After compaction of the waste, it shall be covered with layers of at least 60 cm of soil, inert debris or construction material and shrubs/grass will be planted over piles. To prevent leaching in any rainy season, clay bed of 40cm shall also be prepared before dumping the garbage at dump sites.
2. 100% collection of garbage shall be ensured in all ULBs. Each collection point shall be fully cleared at least twice in a day and it shall be ensured that there is no garbage left over.
3. Burning of dry leaves shall not be allowed.
4. Fully covered vehicles shall be used for shifting Municipal Solid Waste to avoid foul smell and to prevent it from littering while transportaion.
5. To avoid stray animals, fencing around the dump site shall be constructed and completed within two months.
6. A green belt having width of minimum 5 m along the entire boundary/fencing of the dumpsite shall be ensured by growing of dense trees and shrubs for the purpose of greenery and healthy environment of the area. The plantation shall be done during this monsoon season.
7. All ULBs shall ensure spray of herbal sanitizers on waste piles daily on regular basis at the dumping sites to prevent environmental hazard and to retard the foul smell.
8. Fogging shall also be done twice a week at dumping sites to kill insects and flies.
9. Wastes shall be covered immediately or at the end of each working day with minimum 10 cm of soil, inert debris or construction material till such time waste processing facilities for composting or recycling or energy recovery are set up as per Solid Waste Management (Management and Handling) Rules, 2000.
10. In all the Corporation towns and Class-I ULBs, Piezometer shall be installed at dumping sites within two months to monitor the quality of water.

CAP was just a temporary solution to the waste management problem. A long term solution to the problem has to be found. The GoP later realized that waste processing plants like RDF and Waste to Energy will be economically infeasible if ULBs work in isolation. Moreover, there is not even to enough land and resources to construct a separate landfill site for each ULB. Thus, an 8 cluster approach is proposed to be followed in Punjab. Punjab has been divided into 8 clusters: Jalandhar, Bathinda, Ludhiana, Ferozepur, Amritsar, GMADA, Patiala and Pathankot (Table 2). Private partners have been identified for the first four clusters and the implementation is yet to be started in the remaining four. The key highlights of the model municipal solid waste management plan are centralized cluster approach and integrated waste management. Integrated waste management means one private operator will be responsible for Collection, Transportation, Processing and Dumping of waste.

Table 2: Cluster approach in Punjab to manage Municipal Solid Waste

Name of the cluster	Areas covered/ Numbers of ULBs covered	Capacity in TPD	Facility for processing and disposal	Project Cost (Rs. in Crs.)	Private Partner
Ludhiana Cluster	14 ULBs	1125 TPD	49.5 acres of land Jamalpur; 33 acres of land at Jaipur	97.85	M/s. A2Z Infrastructure Limited
Jalandhar Cluster	27 ULBs	750 TPD	20 acres of land at village Jamsher	133.33	M/s. JITF Urban Infrastructure Limited, New Delhi (JINDAL Group); and M/s Ladurner Impainti s.r.l., Italy
Bathinda Cluster	16 ULBs	350 TPD	36.11 acres of land at village Mandi Khurad	66.46	M/s. JITF Urban Infrastructure Limited, New Delhi (JINDAL Group); and M/s Ladurner Impainti s.r.l., Italy
Ferozpur Cluster	18 ULBs	300 TPD	20 acres of land in village Beer Chahal	66.46	M/s. JITF Urban Infrastructure Limited, New Delhi (JINDAL Group); and M/s Ladurner Impainti s.r.l., Italy
Amritsar Cluster	8 ULBs	650 TPD	21 acres at Bhagtanwala	116.00	Two bids have been received and the bids are under evaluation
GMADA Cluster	18 ULBs	350 TPD	50 acres of land at Samgauli	80.00	The bidding process would be initiated soon after the clarity on land acquisition process.
Patiala Cluster	25 ULBs	500 TPD	Site at village Simgauli	95.00	Project under development
Pathankot Cluster	13 ULBs	250 TPD	Site at village Deriwal – 40 acres	55.00	Project under development

Source: (Punjab Pollution Conbtrol Board, 2014)

It is also realized by State Government that the lack of segregated waste could be a challenge for processing of the solid waste. Although the proposed plan mentions that source segregation can be achieved through door to door collection by private players, the Government still has doubts. Therefore processing techniques to handle mixed waste are being explored. It is realized that the private operators enter with a business to make profit and past experiences make it clear that they drop out once the project becomes economically unfeasible. Tipping fee and viability gap funding is not a permanent solution to this problem. On the other hand, ULBs themselves are incapable of operating high-tech waste processing plants. Many a times it also observed that RDF produced by the waste processing units have no buyers due to poor quality which eventually leads to the failure of plants. Similarly there is no fixed tariff for the electricity produced by waste.

Local public has shown resistance to the proposed user fee charges which are proposed to be included in the electricity bill. Moreover, there is already an existing informal door to door collection system in some ULBs and the rag pickers also collect the waste which might to be useful for running WtE plants. Thus, a conflict is foreseen once the private operators take charge of waste collection in ULBs.

Public agitations and protests are often observed when a new plan is introduced. This happens due to plans being formulated without proper consultation of the relevant stakeholders. Thus, it is advisable that before the actual planning of municipal waste management plan the ULBs must identify stakeholders in the regions which might get affected by the plan or have an important say e.g., CBOs, rag picker associations, financing agencies etc. The next step is the formation a steering committee with representation of all the relevant stakeholders. This committee can then plan the waste management system for the locality. Such a procedure could be time consuming but this could be a measure taken to avoid conflicts while implementation of plans.

The major challenges apart from the above mentioned are:

- Abundance of plastic waste.
- Most viable option to handle mixed waste
- Transportation of waste in the clusters on daily basis.

A high powered committee is headed by the chief secretary who regularly monitors the development in this sector.

Following institutional set up is suggested by the department of local government, Government of Punjab, in order to manage waste in an efficient and organized manner. As clear from the framework, committees have been formed both at cluster level and state level to ensure better accountability.

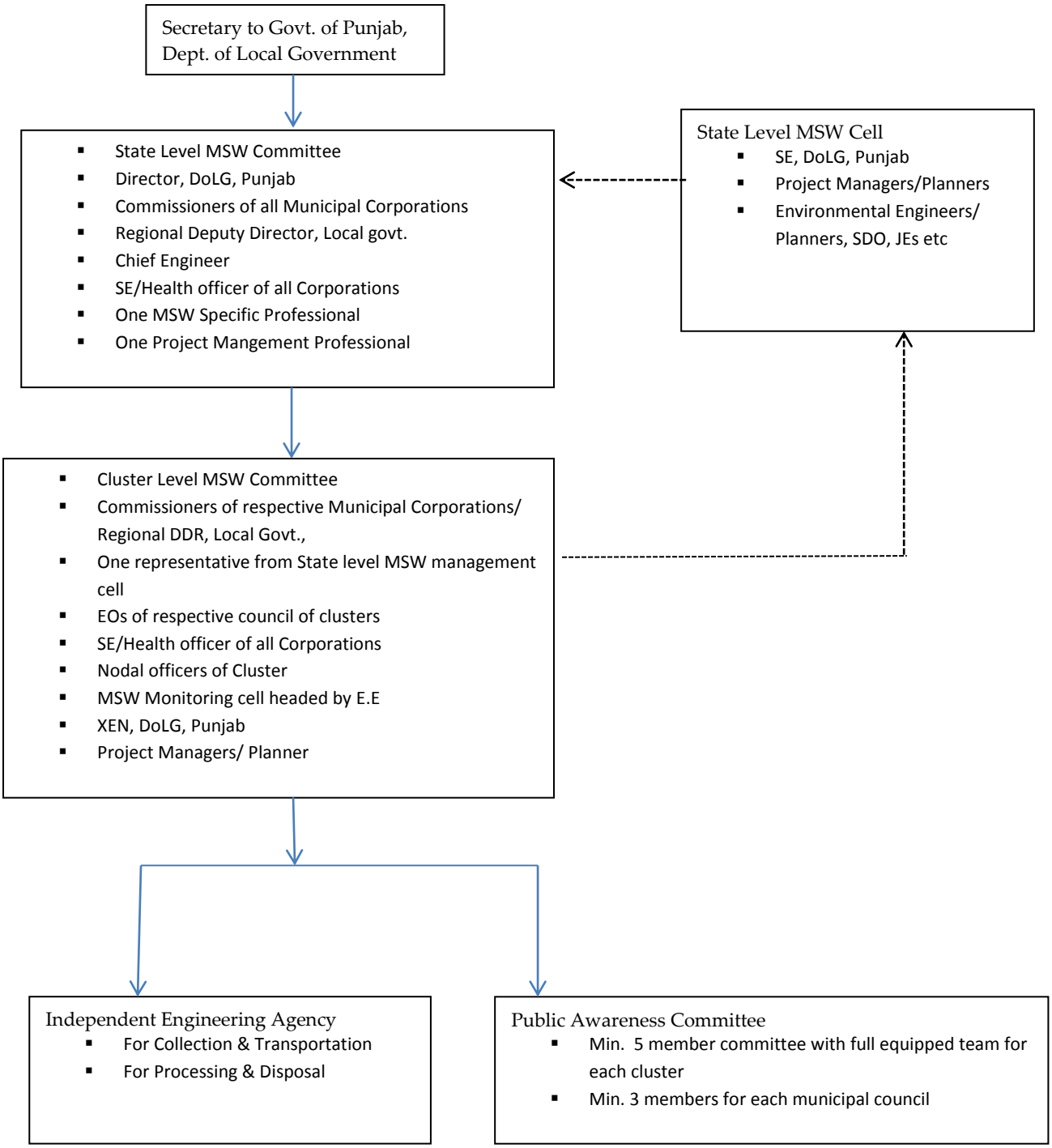

Figure 1: Organizational framework waste management in Punjab

Source: (Department of Local Government, GoP, 2014)

3 International practices

3.1 Brazil

The specific objectives of Brazilian national policy for solid waste management and the Law include:

- Adherence to waste hierarchy - a) reduce b) reuse c) recycle d) disposal of treated solid waste in an ecological manner must be promoted.
- The industries must be incentivized to use recycled products.
- Environmental impacts must be minimized by adopting, developing and improving clean technologies.
- Integrating reusable and recyclable material collectors in actions that involve joint liability for product life cycle.
- Preference to green procurement i.e. purchase of recycled and recyclable products, goods, services and so on, such that it promotes social and environmental sustainability. (al, 2013)

The Brazilian government, in 2014, decided that all the unregulated landfills must be shut down. Moreover, individual or entities not complying with policies and are responsible for damage to environment are required to compensate the government for remedial actions.

3.2 Europe

Many initiatives have also been taken by the European governments to ensure the safe disposal of solid waste to promote sustainability. Improvement in the efficiency of waste treatment and disposal facilities, diversion of bio waste from landfills to reduce GHG emissions, replacement of mineral fertilizers with organic fertilizers (compost) and an improvement in the output from recycling units to reduce natural resource consumptions are some of the steps taken.

The Bio-degradable waste management (BMW) systems, in Netherlands, Austria and United Kingdom, focus on building separate collection systems like specific bins which would eventually lead to BMW treatment systems. In addition, some economic instruments like Pay-As-You-Throw (PAYT) and organic waste tax have been used as an incentive so that the residents' themselves divert BMW from the regular waste. Landfill Allowance Trading System (LATS), another such initiative by the UK government, provided the local authorities the flexibility to manage waste more efficiently.

In 1990 another waste management system – 'Duales (Dual) System Deutschland DSD', was introduced in Germany and then later replicated all over Europe. The main idea behind this was to transfer the responsibility of collection and recycling of main packaging on the producer itself. The packaging is typically marked with a 'green dot' to identify that it belongs to the DSD system. However, in Denmark, it was observed that there was no responsibility of producers in handling the packaging waste, this increased the uncertainty in the estimation of waste and then consequently resulting in higher waste management cost for the local bodies. In the Danish waste management system, all types wastes, irrespective of the type and origin, are to be handled by the local bodies. The segregation of the waste is done at source itself. The financing of the system is through the polluter-pays-policy. (Pires, Martinhi, & Chang, 2010).

4 Fees and Economic Instruments

4.1 Fees and municipal solid waste

The private operators usually charge a 'tipping fee' per ton of the municipal waste handled. For smooth functioning of any project it must be ensured that the tipping fee is provided on time. The GoP is planning to make special provision for this need. A state level fund will be created to meet the expenses of MSW committees at state and cluster level, independent agencies and provide loans to ULBs which is enough to pay the tipping fee for atleast 3 months. This fund will be monitored by the director, DoLG (Department of Local Government), GoP.

Moreover, the Punjab government is also planning to implement the 'polluter pays principle'. This is being done by charging user fee from the waste generators. Table 2 shows the proposed user fee charges. The major challenge in collecting user fee is the strong resistance from the citizens and lack of political will to implement it. Thus, to improve the collection efficiency of user fee it is now proposed that these charges should be included in electricity bill. (Department of Local Government, GoP, 2014)

Table 3: Proposed user fee charges in Punjab

Category Type	Area	Rates per month
Residential	Slum Area	10
	Upto 50 sq mt	20
	51 – 150 sq mt	30
	Above 150 sq mt	50
Hotel	Upto 5 rooms	500
	5-20 rooms	1000
	Above 21 room	2000
Restaurant	Upto 50 sq ft	500
	51-200 sq ft	1000
	Above 200 sq ft	1000
Factory / Production & Trading houses	Upto 1000 sq ft	50 per sq yd
	Above 1000 sq ft	
Shopping Mall	Upto 50 shops	200 per shop
	51-100 shops	
	Above 101	shops
Marriage Places/ Banquet halls	Upto 500 sq yards	8000 per year

Category Type	Area	Rates per month
	501 – 1000 sq yards	12000 per year
	Above 1000 sq yards	25000 per year
Schools	Primary & Play group	100
	Matric	200
	Senior secondary school	1000
College		3000
Educational Institutes		250
University		25000

Source: (Department of Local Government, GoP, 2014)

4.2 Use of economic instruments

A report by European Commission in 2012 recommended some economic instruments which may result in an efficient waste management.

- Disposal of waste is the least preferred option in the waste management hierarchy, as mentioned earlier. Introduction of landfill taxes could be a way to discourage disposal of waste and promote reuse and recycling.

- The responsibility of management of certain mass produced products must be on the producers. The study reveals that arrangements like a private body specifically designed for collection and recycling of waste owned collectively by obligated producers are successful. The producers must be fully responsible for funding the schemes and then later recover the costs by marketing the recycled products. The success of 'Fost Plus packaging' EPR scheme in Belgium which achieves 92% collection and 95% recycling proves the efficiency of EPR.

- While managing solid waste priority must be on the hierarchy in which the management is preferred. The Pay As You Throw (PAYT) scheme promotes the hierarchy. The aim of PAYT is to structure charging system, at the collection level, in such a way that the residual waste in the waste stream in minimal. This will encourage the recycling of the waste.

- Imposing taxes on virgin materials will encourage re-use and recycling of the waste material. However, in practice, this scheme has many obstacles. For instance, the challenge to the implementation of this scheme in EU was the ongoing trade within the EU countries and also between EU and other nations.

- The quantity of residual waste generated per inhabitant of a household is an indicator of consumption level and the degree to which the waste generated is recycled and reused.

Establishing a benchmark of residual waste per inhabitant of a household and then imposing proportional taxes for exceeding the benchmark and re-imbursements for generating less waste could be employed to discourage waste generation.

- Existing VAT Directive (2006/112/EC) is another way of reducing the waste, for example, reduced VAT on repairing large household appliances is step towards promotion of re-use rather than increasing consumption.

5 Use of Technologies

5.1 Recycling and Waste-to-Energy

The waste generated in Punjab is composed of recyclable waste – 13%, compostable material - 36-44% and inert material 40-50% (PPCB, 2013). This waste composition indicates that the waste generated has a high potential to be treated and re-utilized. The organic waste can be composted and recyclable waste can be used for material recovery. However, as mentioned earlier, the actual situation is opposite.

Improving the waste collection efficiency and developing suitable technologies for waste segregation, transportation, treatment and disposal could be a step towards the solution of this problem. Case study 1 and case study 2 are examples of efficient recycling and waste to energy projects in India.

Box 1: Efficient recycling of paper

The amount of paper waste generated in India is increasing as the country is economically progressing. Production of paper has huge direct implication on forest and wildlife. Thus, recycling paper waste is the most logical option. 'Waste to Wealth' was an initiative started by the ITC in 2011. The focus area is south of India, particularly, Hyderabad, Bangalore, Coimbatore and Chennai. IT companies like Infosys, IBM and Wipro have agreed to sell their waste to ITC for recycling. They also plan to tie up with RWAs, NGOs and local bodies.

Source: CPHEEO (2014)

Box 2: Successful bio-methanation plant

The Nisarguna Technology developed by the Babha Atomic Research Centre (BARC) is an improvement over the traditional Gobar Gas plants to generate methane for energy purposes. The improvement in the design prevents choking and allows the plant to treat a variety of waste feed. In 1998, the Municipal Corporation of Greater Mumbai, Stree Mukti Sanghatana, Bhabha Atomic Research Centre, Waste pickers cooperatives and Navi Mumbai Municipal Corporation collaborated together to manage the municipal waste by incorporating The Nasirguna Biogas Technology.

Source: CPHEEO (2014)

5.2 Deployment of Information Technology

Smart Waste Management System: The major problem with the waste management system in India is inefficiency is waste collection and transportation. A nationwide intervention is required in collection and transportation system.

Smart waste management system (SM-WMS) is providing logistic solutions and constantly developing the mechanism according to needs and previous learning. These solutions are usually a combination of hardware and software developed by IT professionals. The basic objective is to minimize time consumption and investment, and maximize the quality of the service provided. For instance, the collection system can be improvised if the quantity and quality of the waste collected is regularly monitored. This knowledge will eventually help in better planning of collection routes, types of vehicles to be used and identification of critical areas which, probably, need special attention. Technologies like optical sensors could be used for high quality segregation of waste which will minimize the economic losses and provide a better input for specialized processing units.

The municipal corporation of Coimbatore is using an using an online waste truck monitoring system using radio frequency identification linked with waste transfer stations and processing units. The Bhopal Municipal Corporation saved up to 2000-3000 liters of diesel per day only by installing GPS devices in about 50 waste trucks.

Information Communication Technology: Integrating the information technology with the existing waste management system can have a huge impact on the condition of the waste sector in India. Technologies like GPS, GIS, remote sensing, online web services and cloud computing can find some real time application in waste management. For example, trucks and bins can be installed with remote optical sensors which can constantly record the data of type and amount of waste collected at various locations and create a database. This database can be instrumental in understanding, analyzing and predicting the waste production patterns, and eventually manage waste more efficiently. (Ion & Gheorghe, 2014) (Planning Commission , 2014)

In Punjab, 143 ULBs have been identified as local authorities to manage municipal solid waste of the state. In the municipal solid waste management plan As a step towards integrated municipal waste management approach, the state is divided into 8 clusters. Table 1 shows the details of these eight clusters:

6 Ways Forward

The situation of solid waste management has certainly improved over the years. However, there is still a long way to go. Instead of following the usual end of pipe approach, waste management must be looked at holistically and preference must be given to reduction of waste at the source. The waste management system is blocked at collection stage, which is inefficient and consumes most of the funds and time. Instead of working against the informal sector, it is important to recognize the importance of informal sector and incorporate it into the formal waste collection system. Waste processing and disposal

deserve more strategic and financial importance. There is need to maximize resource recovery from waste and waste recycling to reduce the land requirement for waste disposal.

As regards to municipal solid waste and other urban waste streams like e-waste, construction and demolition debris, partnership of various stakeholders viz. ULBs, private formal and informal waste managers, waste generators, and regulatory agencies need to evolved to ensure that waste management is carried out in most efficient manner. The ULBs in India are not financially strong. The current mechanisms to raise funds for waste management must be improvised. Also, it must be realized that municipalities can no longer 'provide' all the waste management services in isolation. The aspects of waste management which the municipalities can handle efficiently must be identified and private operators must be given a chance to manage the remaining aspects in participatory and transparent manner. The government must alter policies in such a way that private sector is encouraged to invest, establish and operate facilities in the waste management sector. The key strategies for efficient management of waste as part of greening the waste sector would include:

- **Waste reduction strategies**: Waste reduction strategies involve lesser generation of waste at source and using alternative material which generate waste of lesser hazard as compared to traditionally used ones. It is necessary to decouple the waste generation process from the growth of economy and population. Various ways in which this can be achieved are:

  a. Alternative packaging – use of fabric or jute packaging instead of traditionally used polythene bags which are difficult to collect and recycle (reviving of jute sector)

  b. Designing products like cell phones and other electronic goods for longer shelf life so that they enter the waste stream a little later

  c. Designing products for disassembly so that majority of their components can be recycled at the end-of-life

  d. Developing re-manufacturable products to increase their life cycle

- **Waste inventory**: As evident in the case of Punjab and Himachal Pradesh, getting the most credible waste inventory data is a problem. In absence of dynamic waste inventory, long term planning for waste management becomes difficult. Each municipality should maintain a complete database for its waste management activities, particularly generation of waste (daily data), characteristics of waste (monthly data), processing facilities actually installed and operated and their performance (monthly data) and final disposal in a sanitary landfill (monthly data).

- **MSW to composting**: Excessive use of chemical fertilizers and resulting run off is resulting in pollution of soil and water bodies and is key non-point source of pollution. The top soil as a result of over irrigation is also getting depleted in organic carbon which affects soil fertility. As stated earlier, MSW in India comprises of around 50% organic or food waste with high moisture content. This waste (food waste, agricultural residues, etc.) can be composted either aerobically or anaerobically. This process not only treats the waste, diverting it from landfill (thus saving on cost of disposal) but also the compost

produced can enrich the top soil with organic carbon which is key to soil fertility. The process is net GHG saver as compared to open dumping of waste which results in uncontrolled emission of methane. Decentralized, community composting options should be explored wherever feasible (away from residential areas to avoid community conflicts)

- **MSW to energy**: Viability of producing energy from MSW (woody waste, agricultural residues, food waste, waste papers, plastics, etc.) and extraction of landfill gas from 'open but soon to be closed waste dumps' can not only treat the waste but also provide renewable source of energy to 'energy starved' cities. Technologies like anaerobic digestion (producing power as well as compost), use of refuse derives fuel and landfill gas will be explored for processing such waste. These processes also would be net GHG saver as compared to open dumping of waste which results in uncontrolled emission of methane. Decentralized biomethanation options as implanted in Pune should be explored for other cities as well. The Ministry of New and Renewable Energy (MNRE) estimates that there is potential of generating around 2500 MW of energy from processing of waste in the country.

- **Material recovery and recycling**: India reportedly salvages and recycles around 70% of MSW, though most of it is collected and recycled by informal sector using rudimentary technologies. It is reported that in developing countries around 15-20 million people are engaged in waste recycling activities – in some cities 2% of the population. More than 1 million people are engaged in waste recycling activities in India. It is also reported that informal sector (waste pickers) remove around 10-15% of waste every day from city streets and are key to solid waste management system in any city. There should be efforts to institutionalize informal sector and modernization of recycling technologies. Informal waste recyclers can be trained to collect the waste from households, do decentralised waste processing (composting or biogas) and trade recyclable waste as is demonstrated by Stree Mukti Sangathan in Mumbai.

6.1 Need for funding

The goals of greening the waste sector cannot be achieved without increased investment. Minimising waste generation requires changes to product design and production processes upstream. Downstream recovering, remanufacturing, recycling, and final treatment require new facilities or upgrading of existing facilities. Investment is also needed to train the labour force in the sector as well as to formalise the informal sector.

Cities in India typically spend more than half of their waste budget in collection alone (mainly on labour and fuel), although the collection rate remains low and the transport of waste inefficient. Spending on other segments of the waste management chain such as appropriate treatment, recovery and disposal technologies and facilities is generally rather low. Increased investment in basic collection services, the transport of waste and cleaning up dumpsites is a starting point for greening the sector. Investment can be targeted, for example, at techniques such as route optimisation and transfer stations, which can bring down the capital and operational costs of providing waste services.

6.2 Benefits of Greening the Waste Sector

Greening the waste sector is expected to generate substantial economic, environmental and social benefits. They include: 1) natural resource and energy saving; 2) creation of new businesses and jobs; 3) compost production supporting organic agriculture; 4) energy production from waste; 5) reduced GHG emissions; and 6) contributions to equity and poverty eradication. Improved health, avoided health costs, avoided water contamination, and the consequent cost of alternative water supply are also important streams of benefits.

Though the figures for job creation while greening the sector is not available as of now for India; similar experiences in other developing countries show that the activity does create better quality of jobs. Over half a million waste pickers have been reported in Brazil and the country has close to 2,400 companies and cooperatives involved in recycling and scrap trading (UNEP 2008). In Buenos Aires, an estimated 40,000 waste scavengers are estimated to have an economic impact of US$1.78 million per year, close to 0.05 per cent of the city's GDP (Medina 2008). Other estimates put the number of waste scavengers in India at least at a million, while in China up to 10 million workers are reportedly involved in recycling activities (UNEP 2008). Scheinberg et al. (2010) studied informal recyclers in six cities: Cairo, Egypt; Cluj-Napoca, Romania; Lima, Peru; Lusaka, Zambia; Pune, India; and Quezon City (part of Metro Manila), the Philippines, and found that more than 75,000 individuals and their families are engaged in recycling about 3 million tonnes of waste per year with an economic value of more than US$ 120 million.

6.3 Enabling conditions

1. **Finance**: Investing in greening the waste sector requires substantial financial resources for both capital expenditures and operation. Such resources may be found from: 1) private investments; 2) international funding 3) cost recovery from users; and 4) other innovative financing mechanisms.

2. **Incentives and disincentives**: Economic incentives and disincentives serve to motivate consumers and businesses to reduce waste generation and dispose of waste responsibly, thereby contributing to increased demand for greening the waste sector.

   The incentives commonly prevalent in the waste sector include: 1) taxes and fees; 2) recycling credit and other forms of subsidies; 3) deposit-refund; and 4) standards and performance bond or environmental guarantee fund. Volumetric landfill taxes can encourage the reduction of waste and are easy to implement. Their effectiveness, however, depends on the tax rate per tonne of waste and on the existence of adequate monitoring and enforcement measures. It is also important to ensure that the tax does not result in increased illegal dumping rather than encouraging 3Rs.

   Pay-as-you-throw (PAYT) is another way of discouraging waste generation. Precaution against illegal waste dumping or misuse of recycling facilities is however needed. Full financing of the waste-management infrastructure has to be assured and sufficient awareness-raising is necessary. PAYT has a positive impact on recycling. For example, PAYT increased the recycling rate from 7 per cent to 35 per cent in Portland, Oregon and

from 21 per cent to 50 per cent in Falmouth, Maine in just one year of implementation (Shawnee Kansas 2009).

Waste avoidance can also be achieved by assigning a disincentive for items such as plastic bags. For example, Nagoya city in Japan, after extensive consultation with retailing companies and two years of piloting, assigned a charge for plastic shopping bags in April 2009. The scheme was adopted by 90 per cent of the shopping market. The initiative reduced plastic-bag usage during shopping by 90 per cent as of December 2009. About 320 million bags weighing 2,233 tonnes were estimated to have been saved between October 2007 and October 2009 (Environmental Affairs Bureau 2010).

3. **Institutional arrangement between formal and informal sectors**: It is important to formalise the informal sector enterprises and support them through incentives in order to develop local markets and small and medium formal recycling enterprises. Incentivising formal recycling activities, providing micro-finance and access to the markets could help in shifting the informal sector to formal regime. In addition, raising awareness on the social and health related benefits of formalisation may help in understanding importance of intangible benefits.

4. **Policy and regulatory measures**: The most common types of policy and regulatory measures include:

   - Regulated targets for minimisation, reuse, recycling; and required targets for virgin materials displacement in production inputs;

   - Regulation relevant to the waste management "market", i.e. permitting/licensing requirements for waste handling, storage, treatment and final disposal; and recycled materials standards; facilities standards, including pollution control technologies; and

   - Land-use policies and planning for siting waste processing and disposal infrastructure.

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