



**ICRIER's Program on Capacity Building and Knowledge Dissemination on Urbanization
in India**

**Summary of the Workshop on
*Challenges of Urban Development in India's Hill States with focus on Solid Waste
Management***

**Participating states: Assam, Chandigarh, Haryana, Himachal Pradesh, Meghalaya,
Mizoram, Punjab and Uttarakhand**

In Partnership with Himachal Pradesh Institute of Public Administration

Shimla

May 30, 2014

Session I: Challenges of Urbanisation in India

Dr Rajat Kathuria, Director and CEO of ICRIER, inaugurated the workshop by welcoming Mr Sanjay Chauhan, Mayor of Shimla Municipal Corporation, as well as the participants. He went on to thank Himachal Pradesh Institute of Public Administration (HIPA) for co-hosting the workshop with ICRIER.

Address by the Chief Guest, Shri Sanjay Chauhan, Honourable Mayor of Shimla Municipal Corporation, Himachal Pradesh

- Urbanisation is one of the greatest challenges that India and other countries in the world are facing. We must look back and learn from the past to analyse how we should take urbanisation forward.
- India has been predominantly agrarian and agricultural waste has historically been recycled and managed scientifically. This practice must be extended to all sectors of the economy.
- A few decades ago, citizens would struggle to get water. Over the years, with increasing awareness, citizens have started to expect immediate action from the authorities concerned to fix the problem if there is a sudden shortage in water supply.
- The use of polythene has been completely banned in Himachal Pradesh. These kinds of policies will only be successful if the beneficiaries cooperate to successfully implement the same.

Ms Shraddha Suresh, Research Assistant, ICRIER

- India is heavily under-urbanised with only 31% of the population living in urban areas. This is much lower than in some of the other countries that India is usually compared to.
- Out of 12 selected states (Arunachal Pradesh, Assam, Chandigarh, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and Uttarakhand), only Mizoram and Chandigarh have urbanisation levels higher than the

national average of 31% in 2011. Himachal Pradesh has by far the lowest share of urban population.

- States with higher per capita incomes have higher levels of urbanisation. Besides Chandigarh and Mizoram, Jammu and Kashmir and Manipur have urbanisation levels higher than expected given their income levels.
- India's urban population is projected to increase from 377 million in 2011 to 600 million by 2031 and the number of metropolitan cities is projected to increase from 52 in 2011 to 87 by 2031. Of the 12 selected states and union territories, only Jammu & Kashmir has Srinagar which is a metropolitan city.
- Most of the cities in 11 selected states (Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Uttarakhand), have populations below 20,000.
- According to the latest Census data, in 6 out of the 12 states, there was parallel increase in the number of Census Towns and Statutory Towns. In 4 states, there is need to recognise urbanisation which is a more typical experience across India, with the number of census towns increasing much more than the number of statutory towns. In 2 states, Arunachal Pradesh and Nagaland, we see the opposite.
- Biodegradables make up 51.3% of municipal solid waste in India. Recyclables account for 17.5% and inert material 31.2%. The moisture content of the waste is 47% and its calorific value is 7.3 mega joules per kg.
- The volume of municipal solid waste in India has increased from 45.9 million tonnes per year in 2001 to 68.8 million tonnes per year in 2011 and is projected to increase to 165.0 million tonnes per year by 2031. Similarly, per capita waste generation has increased from 0.4 kg/day in 2001 to 0.5 kg/day in 2011 and is projected to increase to 0.7 kg/day in 2031. The share of biodegradables has increased from 42.2% in 1996 to 52.3% in 2011. The share of plastics and rubber has also increased, from 0.6% in 1996 to 7.9% in 2011.
- GDP growth in Himachal Pradesh and in India as a whole has slowed down in recent years. Growth in Chandigarh, Arunachal Pradesh, Assam, Meghalaya and Mizoram has also decelerated. GDP growth in Manipur has accelerated in the last few years, whereas Sikkim and Uttarakhand have registered a sharp decline in growth.

- Rapid growth has meant that as the Indian economy goes through a major structural transformation, urban share of GDP is rising rapidly.
- The pressure of rural-urban migration will increase further with increasing role of industry and services sector in growth and with more labour absorbing growth resulting from increasing integration with the world economy. Many cities will experience peripheral expansion, with smaller municipalities and large villages surrounding the core city becoming part of the metropolitan area. Since we only have data for 2001, there is need to watch out for Census 2011 figures because there is every expectation that the 20% or so of migration will be much more in 2011.
- An important message from the HPEC report is that to sustain growth rates of GDP of 8% per annum, or to sustain per capita income increases of about 5.5 to 6.5 per cent per annum, faster GDP growth has to come from industry and services, since agriculture at best can grow at 4 to 4.5 per cent per annum. To make growth of industry and services more labour intensive, there is need to (i) modernise labour laws (to provide greater flexibility in hiring and firing labour) and (ii) provide social protection to those who do not find productive employment in the organised sector. A very important message from the HPEC report is that the fortunes of the rural sector are crucially linked to the manner in which growth in the industrial and services sector unfolds.
- We keep hearing about the demographic dividend that India is currently experiencing, but it is better to speak in terms of demographic opportunity rather than demographic dividend. The share of China's working age population has begun to decline from 2010 onwards, and the share of Brazil's working age population is projected to decline from 2020 onwards. On the other hand, the share of India's working age population is projected to increase up to 2040. In order to convert the demographic opportunity into a demographic dividend, we must empower the youth with education, skills and innovative capacity and must expand employment opportunities. Growth must be made more employment intensive in order to reap the demographic dividend.
- Coming to the implications for urban development, the ground reality is that the cities and towns of India are visibly deficient in the quality of services they provide and that the current state of service delivery is far short of what is needed to realise the economic potential of urban areas. The way forward includes (i) creating urban infrastructure, (ii)

reforming governance for service delivery, (iii) providing access to universal service standards for all including the poor, (iv) consciously building rural-urban synergy, (v) recognising importance of urban transport, (vi) integrating transport and land use planning and finally, focusing on metropolitan planning.

- The services standards put out by the Ministry of Urban Development in 2008 were displayed on the screen.
- The HPEC was asked to provide an estimate of the urban infrastructure investment requirement over the 20-year period 2012-2031. The Committee estimated an investment requirement of Rs 39.2 lakh crores for urban infrastructure, including for slum redevelopment and capacity building, over this period. This is assuming that all the unserved and underserved population between 2012 and 2031 will be covered, all the additional population will be covered and that service standards will match the norms set by the Ministry of Urban Development. The HPEC felt that these norms must be made universal. It is also important to note that this estimate is based on 2009-10 prices and that it does not include primary education, primary health, electricity distribution and land cost. GDP is assumed to increase at 8 per cent per annum for the 20-year period.
- This investment requirement would imply that investment in urban infrastructure must increase by 15% per annum over the 12th Five Year Plan, by 12% per annum over the 13th Five Year Plan and by 8% per annum over the 14th and the 15th Five Year Plan periods. The cost of operations and maintenance is estimated at an additional Rs 20 lakh crore for old and new assets together.
- Out of the total investment requirement of Rs 39.2 lakh crore, 8 major sectors mentioned here account for an investment requirement of Rs. 34 lakh crore. Interestingly, two-thirds of this investment requirement, amounting to Rs 23 lakh crore, is for urban roads, transport and traffic support infrastructure, where the backlog is very large. Just about one-fourth of this requirement is for water, sewerage, solid waste management, storm water drains and street lighting. Other sectors account for 9% of this investment requirement, which amounts to Rs. 3.1 lakh crore.
- Total expenditure on the urban sector amounted to 1.59% of GDP in 2011-12. The HPEC felt that this must increase to 2.16% of GDP by 2031-32, which is not a very large increase. The sums of money required for investment in urban infrastructure are very

large, but they can be financed if the Government of India scales up urban development funding through programs such as the JNNURM from 0.1% of GDP in 2011-12 to 0.25 per cent of GDP per year for 20 years. State governments must enter into constitutionally mandated revenue-sharing arrangement with ULBs and must provide them with an enabling environment to reform. This would actually lead to a drop in transfers from state governments from 0.32% of GDP in 2011-12 to about 0.16% of GDP in 2031-32. On the other hand, ULBs must also aggressively push reforms in order to increase their own revenues, which only accounted for 0.5% of GDP in 2011-12, which was less than one-third of total expenditure on the urban sector in that year. The HPEC recommends that this must increase to 1.47% of GDP by 2031-32. To make access to borrowing and PPP possible, ULBs must work on a Revenue Model which makes them both credit-worthy and market-worthy.

- In order to reach the recommended levels of investment, it is important to note that governance is crucial because financing is crucially dependent on the reform of institutions and the capacity of those who run the institutions for service delivery and revenue generation. Municipal entities need to be empowered to raise 'own' sources of revenue. It is also important to have predictable transfers from state governments, and other transfers from the Government of India and state governments, to help them discharge the larger responsibilities assigned to them by the 74th Constitutional Amendment. The ULBs themselves need to carry out reforms to strengthen their finances, and to improve service delivery. For this, building and developing a Municipal cadre is very important.
- The JNNURM has created dynamism in the Indian urban sector which has long suffered neglect. But progress in implementing reforms under the JNNURM has been slow. The Mission has generally exposed the lack of capacity to prepare and implement projects in urban infrastructure within an integrated framework of a City Development Plan.
- The recommendations of the HPEC report have already been circulated. Some of the key recommendations are: (i) because capacity building is so important, the HPEC recommends having municipal cadres so that trained municipal staff will continue to stay on and work for the municipality (ii) it is very important to have automatic, guaranteed and predictable transfers to the third tier, say 0.25% of the GST, which should be

specified in advance to provide the necessary oxygen to ULBs (iii) the government has recently started the process of merging the Ministry of Urban Development and the Ministry of Housing and Urban Poverty Alleviation. This was a very important recommendation of the HPEC, because we cannot plan for the poor outside of urban development (iv) since the JNNURM has now come to an end, there should be a program like the JNNURM which links funding for urban development to reforms in governance.

Discussion

- The HPEC's assumption of GDP growth at 8% per annum does not hold. Some figures from the report will have to be changed to account for changing circumstances.
- The investment requirements have been calculated keeping in mind the service standards set out by the Ministry of Urban Development. For some sectors, such as transport, regional variation has been accounted for. For instance, a BRTS might be optimal for a larger city but not a smaller city.
- The criterion for giving assistance to cities for infrastructure development under the JNNURM is based on populations. Shimla is a mission city by default under JNNURM by virtue of its being the capital of Himachal Pradesh. One concern for the hilly regions is that when population is the only criterion, none of the hilly areas can come under the purview of the JNNURM. The selection criteria for mission cities under the JNNURM need to be tweaked.
- Himachal Pradesh has a significant floating population of tourists. For every Himachali, there are 2.5 people from outside. This implies additional infrastructural concerns because Himachal Pradesh is a popular tourist destination.
- While providing funding under JNNURM II, there is need to look at the small ULBs which seem to be invisible but are required to perform. It will be very difficult for them to comply with reforms if they don't have a trained accountant, computer specialist, spatial planner and engineer at the very least. Six months could be given to put these people in place before giving the program money. The ratio of funding could vary depending on the size of the ULB.

- There is currently no overarching umbrella of outcomes within which projects are specifically geared towards achieving those outcomes. An ADB project for urban development has been formulated along these lines in Himachal Pradesh with funding of Rs 700 crore, but is currently on the backburner.
- Manpower is needed before capacities can be built. ULBs are not even able to replace officers who retire. Even with funding, it is difficult for ULBs to perform their duties because they lack trained staff.
- 10 out of 12 districts in Himachal Pradesh are urban. 6 specialists forming a kind of project implementation unit are going to be made available to these districts. These specialists will have to be oriented towards the development of hilly areas and assisted by the local staff.
- The Service Level Benchmarks set out by the Ministry of Urban Development outline how to collect data on service provision. To enable the team of specialists to give their suggestions on planning, it is essential to create a reliable database on service provision, which is currently not available.
- Projects like the JNNURM must provide specific guidelines relevant to hilly states instead of clubbing them with plain areas. This should be done for all sectors, not just for solid waste management.
- In the experience of the Himachal Pradesh State Pollution Control Board, the data collected from ULBs is generally not correct. For example, Solan claims to collect 50,000 kg of plastic waste per annum. In contrast, Baddi (an industrial hub where the ban on plastic has not been successfully implemented) claims that only 100 kg of plastics are collected per annum. A log book on waste collected must be maintained to generate a reliable database.
- Only 25% of Shimla is accessible by vehicles. It is very difficult to bring solid waste to the processing sites.
- Service Level Benchmarks set out by the Ministry of Urban Development do not need to be re-formulated for the hilly states. It would be better to look at their relevance to each area's needs rather than trying to re-invent the wheel.
- There is urgent need for waste auditing to be carried out regularly.
- Any policy suggestion, however good, will come to naught if it is not implemented.

Session II: Challenges of Integrated Management of Municipal Waste: Segregation, Collection, Transportation, Recycling and Disposal

Dr. Purnima Chauhan, Commissioner, Departmental Enquiries and Special Secretary, Urban Department, Government of Himachal Pradesh chaired the session.

Dr. Purnima Chauhan, Commissioner, Departmental Enquiries and Special Secretary, Urban Department, Government of Himachal Pradesh

- Mountains are very important for their natural resources. It is essential to manage solid waste in order to protect the environment of the hills, which is important to the plains as well.
- The HPEC recommendations are very important because cities are the engines of growth.
- There is a reluctance to convert from rural to urban because rural areas receive more funds and have to pay fewer taxes.
- If people believe that services will definitely be provided, they may be more willing to bear the higher tax burden imposed on urban areas.
- Slums are a growing concern especially in terms of the lack of appropriate solid waste management which is why the IHSDP and BSUP are being merged into RAY.
- Water, sewerage, solid waste management and storm water drainage must be looked at together.
- Pollution on the part of tourists in Shimla is a major concern. The locals are more environmentally sensitive.
- Data must be made available to all citizens, to promote collective responsibility.
- Financing urban projects is a challenge. Solid waste is not a profit centre. The O&M costs can be so high that recovering these amounts would be difficult. Hilly areas are special category states under the JNNURM, so they only need to be able to recover 50% of O&M costs (unlike non-special category states which need to recover 100% of O&M costs). Special category states must use this advantage. There is need for accrual-based accounting. Assets must be leveraged to raise funds. Better collection of property tax.

Cross subsidies for essential services like SWM. As a last resort – go to the GoI for viability gap funding. Some amendments were made to the Himachal Pradesh Municipal Corporation Act in 2011 and 2013 so that the ULBs can decide how to use their resource base (especially property tax). Such amendments were a pre-condition for receiving funds according to the 13th Finance Commission.

- Infrastructural bottlenecks also exist in rural areas which is why it is important to note the HPEC's recommendation to build rural-urban synergies. It is also important to collaborate with rural areas because they may not generate enough solid waste to make viable for them to treat it independently.
- Real estate developers look to rural areas for buying cheap land to build “summer homes” for people living outside hilly areas. The Town and Country Planning Act in Shimla was recently amended so as to apply the same regulations to rural areas that are imposed on urban areas. This should be extended to the entire state. There could be a negative list (eg. for cowsheds etc) to deal with apprehension towards the TCP Act on the part of people living in rural areas.
- Funding under JNNURM is going to fall over the next 2 decades. Special category states say that ULBs must generate their own funds and must take tough decisions regarding user charges. Thus ULBs must enhance their capability to generate funds.
- Shimla distributed 2 dustbins for wet and dry waste to its citizens with a security of Rs 100. One lady refused to carry unsegregated waste uphill. In doing that, the citizens in her area were forced to segregate their own waste. But the garbage truck did not have two separate chambers for wet and dry waste, and the waste ended up being mixed. Thus, there is need to look at where one person's responsibility ends and another person's begins. We must also look at what kind of equipment is provided.
- Mountain areas have no arterial roads. This leads to extra transportation costs for solid waste.
- There is currently a deficit of 18.78 million dwelling units. 73% of which is in the bottom 40% of the population, comprising of the economically weaker sections and low income groups. As the gap in housing is met, there will be a major increase in municipal solid waste generation.

- Institutional hierarchical structures at the district level are lacking. Between the Director, Urban Development and the ULB, the Deputy Commissioners have very little role to play in urbanisation. It is essential to put in place a municipal cadre.
- Criteria for the Government of India's urban awards are completely oriented towards plain areas. There should be a separate category for hilly areas in order to motivate them.
- One of the important roadblocks to the reforms envisaged by the JNNURM is the lack of citizens' participation.
- The Himachal Pradesh Action Plan on Climate Change has already mapped vulnerable areas in the state. This can be used as a starting point for solid waste management plans and to subsequently avail carbon credits.
- There must be greater convergence between stakeholders in different departments (PCB, ULBs, citizens etc.). RWAs must also be involved. The Pollution Control Board is a sanitation regulator which is held at arm's length.
- We cannot maintain the status quo because this would adversely affect the quality of life and public health. We must involve RWAs, brand solid waste as something that generates wealth.
- Municipalities should raise funds from solid waste and apply the "polluter pays principle" through user charges and tariffs.
- Plastic roads in Himachal Pradesh save 10% of bitumen per km of tarring. The net saving is about Rs 35,000 per km.
- Urban local bodies are only required to maintain the roads, not make them. The State Finance Commission's normative grants are given to ULBs for maintenance. This money can be used elsewhere by ensuring better mixing of plastic with bitumen and long life for the topping. This can be done easily using technology available with the Administrative Staff College of India (ASCI), Hyderabad.
- ACC Barmana uses plastic waste from the Municipal Corporation of Kullu instead of fossil fuels for their cement firing kiln. But the Municipal Corporation of Kullu bears the cost of transportation, which should ideally be shared by both parties.
- 2 pilot projects on solid waste management are in the process of being launched in Sundernagar and Dharamshala in collaboration with the government of the Netherlands.

Ms. Vaishali Nandan, Senior Advisor, Sustainable Urban Habitat, Indo-German Environment Partnership (IGEP) programme, Deutsche Gesellschaft fuer International Zusammenarbeit (GIZ) GmbH

- IGEP is the Indo German Environment Partnership Program. It provides support on industrial and urban issues, particularly to do with municipal solid waste, to 4 cities - Shimla, Tirupati, Nashik, Raipur and some states - Himachal Pradesh, Andhra Pradesh and Chhattisgarh.
- In Shimla, waste has to be carried manually, which makes its transportation complicated.
- Only small vehicles can be used to transport waste in Dharamshala, where the roads are very narrow and winding.
- Talai and Palampur have put in place battery systems for vermi-composting. Unfortunately, these are either too far away or have no operator to make them functional.
- Waste is being recycled in Chamba, and there is some segregation of waste in Nahan.
- Kulu, Manali and Solan have composting facilities.
- Polythene is segregated and taken for co-processing and road tarring in Bilaspur.
- The waste dumping site in Hamirpur at least has a retaining wall to check the contamination of a nearby river, while Chamba has not even put in place a retaining wall.
- Some of the important constraints that hilly areas face when it comes to solid waste management include difficult terrain and land issues. The small size of the towns makes it difficult to organize them in a manner that would attract PPP. There are technical issues, financial issues, institutional issues like lack of staff and lack of technical know-how as well as managerial and implementation issues.
- Himachal Pradesh and most other Indian states are still at the initial phase of municipal solid waste management in which waste is dumped unscientifically and there is low cost recovery. In Himachal Pradesh, there is some progress in implementing the Plastic Waste Rules but the Pollution Control Board seems to be forgetting about the Municipal Solid Waste Rules. Nevertheless, Himachal Pradesh until now has been trying to show the way forward.

- The “waste management hierarchy” stresses the importance of reducing and re-using waste at source before sending some parts of it for recycling, composting and conversion from waste-to-energy. Landfills must be seen as the last resort.
- GIZ has estimated that Himachal Pradesh currently generates 350 tonnes per day of municipal solid waste. By 2020, this is predicted to range between 550 and 1600 tonnes per day, which is still too little to attract large private players.
- At state and city level, there is need to incentivise recycling, recognise and regularise the informal sector, fix user charges/producer charges, encourage political inclusion, extend producer responsibility and prevent the use of wild dumpsites by gradually phasing them out.
- State strategies and regional plans must be prepared which look at financial planning and identify appropriate treatment based on MSW characteristics, flows and an accurate database. The plans must follow the waste hierarchy mentioned earlier, which gives primacy to the principle of reducing, reusing and recycling, and must allocate activities to the local level and the central level. Other important aspects that plans must look at are the identification of regional sites for scientific landfills, closure/rehabilitation of wild dump sites, environmental monitoring, public private participation, stakeholder consultations, integration of the informal sector, reaching out to the un-served/peri-urban areas, and putting in place an effective complaint redressed system.
- Institutional capacity must be built. A separate solid waste management cell may be put in place at the district/state level to monitor all the urban local bodies and at the central level to monitor the formulation and implementation of the SWM strategy. Capacity building for staff, performance incentives linked to improvements in efficiency in terms of service level benchmarks, and deployment of experts in municipal solid waste management are a few other recommendations.
- It is important for the state to create awareness about, especially among school children, about recycling of waste, decentralized waste management systems etc.
- Economically sustainable solid waste management is contingent upon full cost recovery for the entire system, i.e., waste collection, transportation, treatment and disposal.
- The most important step is to create a roadmap for the implementation of the strategies mentioned above with a year-wise plan to push these strategies forward.

Dr. Omesh K. Bharti, Chief Health Officer, Shimla Municipal Corporation

- It is not enough to only look at current cost recovery but also to account for future environmental costs which will not be incurred as a result of putting in place environmentally sustainable processes today.
- Solid waste generation per capita in Shimla has increased from 262 grams per day in 1995 to 350 grams per day in 2013.
- A “door to door” garbage collection scheme was initiated by Shimla Municipal Corporation in 1999 in collaboration with local NGOs. One of the main reasons why this scheme did not work was that user charges were the same across all categories of users (eg. institutions, households etc.). Lack of community participation, inadequate human resources and low wages for the workers also led to the failure of the program. The municipality also tried to charge for the collection of waste on a per kg basis instead of charging for waste per household, owing to increasing financial constraints. This proved to be unsustainable as well.
- Door to Door Garbage Collection bye-laws were put in place by the Municipal Corporation of Shimla in 2006. The Shimla Environment Heritage Conservation and Beautification (SEHB) Society was created by the Municipal Corporation of Shimla in 2009. Ward level committees were formed for managing MSW at ward level. Door to door waste collection was put into operation in April, 2010 and the implementation of the bye-laws was made legally binding on the public. There are provisions for withdrawing or disconnecting basic amenities like water & sewerage connections as well as electricity connections for defaulters. Those who fail to hand over the garbage to SEHB worker are fined by the corporation under various acts. The SEHB society generates revenues of more than Rs 24 lakh per month and is financially sustainable.
- Two different bins (Green & Yellow) are given to each household. User charges range from Rs 40 – 1000 per month and 85% of households are covered. This scheme is running successfully and neighbouring panchayats are paying Rs 100 per household to be brought under this scheme. A complaint redressal system has also been put in place.
- Welfare measures for door to door garbage collectors include contributions to PF, health insurance, leave entitlements and incentives for the sale of recyclables. More than Rs 2

lakh have been spent on providing immunization to workers against rabies. Apart from this, there are regular health check-up camps for workers. The provision of ID cards, emergency compensation and jobs for workers' next of kin are some other important welfare measures.

- To increase door to door garbage collection, the Municipal Corporation of Shimla has been creating awareness by disseminating information through pamphlets/booklets, posters, newspapers, radio and *nukkad nataks* (street plays).
- Some of the proposed improvements to the scheme include setting up a waste transfer station, a GPS enabled routing and loading system, chutes systems for inaccessible areas at higher reaches, decentralized waste treatment units for inaccessible areas downstream, poo bags for horses littering horse-dung all over the Ridge and the installation of bio-converters at places like the *sabzi mandi* (vegetable market) or at big hotels. Efforts are being made to segregate waste and collect the dry waste at one place so as to economize on transport costs and tipping fee.
- The scheme has generated employment for more than 500 individuals and involves community participation, with more than 35,000 households registered.
- The SEHB Society received a Skoch Order of Merit Award and a Medal in the year 2013.

Mr. R.D. Sharma, Unit-In-Charge, Green Tech Fuel Processing Plant (A unit of Jaiprakash Associates Ltd.), Chandigarh

- Chandigarh holds the distinction of being the cleanest city in India.
- Chandigarh has a state-of-the-art municipal solid waste treatment plant. Jaiprakash Associates Ltd. (one of Jaypee Group's companies) conceived this project in 2006, started construction in 2007 and completed it within a year. The plant is fully functional now and can process 500 tonnes of municipal solid waste per day. The project was implemented with technical support from the Technology Information, Forecasting & Assessment Council (TIFAC), an autonomous body under the Ministry of Science and Technology, Government of India. Andhra Pradesh Technology Development Centre was also consulted with.

- Chandigarh has witnessed rapid urbanization and industrialization. As a result, problems associated with municipal solid waste have increased at an alarming rate. Jaypee's Green Tech processing plant uses municipal solid waste to produce refuse derived fuel (RDF). Garbage is collected from each house in every locality and is weighed using an automatic, digital weigh bridge, which records the information on waste. The garbage yard has the capacity to store 5,000 metric tonnes of waste.
- To reduce the stench emanating from the garbage, an eco-friendly solution is sprayed on it. The components of the waste which cannot be used to obtain RDF (ceramics, stones, ferrous material etc.) are manually segregated. This is essential in order to avoid damaging the machinery. The waste is manually checked again on a conveyor belt before it is passed through a suspended magnetic separator to remove ferrous objects. A primary shredder reduces the size of the garbage and de-lumps it. The homogenized material is fed through a rotary screen which screens out the small, bio-degradable material with high moisture content which is abrasive in nature. The large particles are carried further into a dryer system which is unique to the MSW plant and enables it to run throughout the year. It eliminates moisture and facilitates the effective segregation of inert material. Gases are treated in a "multi-cyclone" and clean gases are released into the air. Another magnetic separator screens out the remaining ferrous material from the waste. A ballistic separator then separates the remaining inerts from the combustibles. Heavy material is then separated and the light material goes through a secondary shredder which further reduces its size. The RDF so obtained can be densified as per requirement.
- The entire plant is automatically controlled through a Programmable Logic Controller (PLC) and 4 closed circuit cameras.
- Indian municipal solid waste generally has a calorific value of 800-1,000 kilo calories per kg. Jaypee's technology has helped achieve calorific values in the range of 3,100 – 3,500 kilo calories per kg and can reduce the moisture level of the garbage to about 15%.
- Jaypee has invested over Rs 32 crore for this project without any subsidy or grant from the government. Jaypee does not charge any tipping fee and has been providing its services free of cost to the city.
- The plant helps reduce the emission of methane gas (which gets released due to decomposition of municipal solid waste lying in landfills) and the contamination of

groundwater. It also helps to conserve fossil fuels by providing alternative fuel to industries.

- This plant is registered as a Clean Development Mechanism (CDM) project under the United Nations Framework Convention on Climate Change (UNFCCC).

Discussion

- The problem with transporting plastic from municipalities to cement plants is that its volume is very large even though its weight is very low. A compactor would be needed to compress the waste and reduce transportation costs.
- The focus is now on minimizing municipal solid waste because land is scarce in hilly areas, making landfills an unviable option in the long run.
- Builders coming up in rural areas must develop their own MSW processing facilities.
- The technological expertise for mixing plastic with bitumen and ensuring a long life for the topping of roads is available with the Administrative Staff College of India (ASCI), Hyderabad as well as with the Central Road Research Institute (CRRI).
- Kullu Municipal Corporation sends all of its plastic waste for co-processing to the ACC plant at Barmana. It currently bears the full cost of transporting its waste to the cement plant, which is not advisable. It is important for ULBs to work out cost-sharing agreements with their private partners so as to make the transportation of solid waste to waste-to-energy plants economically viable for both parties.
- Solid waste treatment plants are sometimes left idle, for example in Solan, because the people living in the vicinity are apprehensive about the possibility of a foul smell in the area.
- Kullu Municipal Corporation had recently suggested that a green tax of Rs 100 per household should be levied. This proposal was rejected by the Deputy Commissioner who felt that citizens would be unwilling to pay the additional taxes. It is important to create awareness among citizens about the subsidies that they receive for publicly provided services, so that they will not be averse to paying higher user charges when required.

- It is often forgotten that the media is an important stakeholder that must be involved in publicizing good work in the field of solid waste management in order to attract investors. This would also make citizens more confident that user charges/taxes paid for public services will actually be spent on providing these services and improving the efficiency of service provision. It is also important for the officials involved to be open to questions in order to build trust among the citizens and between different layers of the government itself. Social media is also a very powerful tool.
- Currently only plastic waste is being sent to the ACC plant at Barmana. In contrast, the plants at Jaypee and Hanjer have been removing the organic and inert material from waste and have been using dry waste such as plastics, jute, leftover paper, rubber, thermocol rags, coconut shells, leather etc. as inputs. GIZ has estimated that this material has a calorific value of about 2,300 kilocalories per kg and moisture content of about 15-19 per cent which is acceptable. This waste is shredded at the Jaypee and Hanjer plants, but there is no need to compress or shred the waste. It can simply be baled together in order to avoid incurring the cost of compressing/shredding waste.
- Shimla has no policy to manage storm water and national highways because of which agricultural land ultimately gets damaged. The lack of proper storm water drains has also exacerbated the spread of jaundice. Sometimes storm water drains are connected to sewage lines, which causes waste water to overflow at the sewage treatment plant.

Session III: Technology Options in Waste-to-Energy

Captain J.M. Pathania, Director, Urban Development Department, Shimla was co-chair of the session with Ms Kanak Tiwari, Fellow at ICRIER.

Dr Ketaki Ghatge, Medical Health Officer, Pune Municipal Corporation

- Pune is the 8th largest city in India and the 2nd largest city in the state of Maharashtra. Solid waste management is a critical issue in the face of rapid urbanisation, changing consumer habits and changes in the quality and composition of waste generated.
- Integrated solid waste management would involve managing organic, inorganic and bio-medical waste as well as construction waste and debris, garden, horticultural, vegetable market and slaughterhouse waste.
- PMC currently has 158 tipper trucks. Separate vehicles are used for transporting organic and inorganic waste. Wet and dry waste is transported separately so as to comply with the MSW (2000) rules.
- Waste is collected from 1500 hotels by separate hotel trucks and transported to the 22 bio-methanation plants located all over the city.
- Dumper Placers empty the waste into larger capacity Bulk Refuse Carriers at the transfer stations so as to reduce transportation costs. There are 7 intermediate transfer stations for this purpose.
- Pune generates about 1600 tons of solid waste per day. An average of 197 tons of waste per day is collected. 60% of households have door-to-door coverage and 44% provide segregated waste. Additionally, there are 973 containers and 203 compactor buckets dispersed around Pune.
- SWaCH Cooperative is a joint effort of PMC with a local trade union of waste pickers. It is fully owned by the latter. Under this initiative, ward wise average collection of waste per day ranges from 350-750 grams per capita.
- Coming to PMC's performance in achieving service delivery up to the standards of the service level benchmarks, 100 per cent coverage/efficiency has almost been reached in terms of MSW collection, recovery, processing, and provision of an efficient complaint

redressal system. However, PMC is somewhat lagging behind in terms of waste segregation.

- The route map along with timings of the tipper trucks is displayed on PMCs website. If the truck does not come at the stipulated time, citizens may contact the officials concerned and the issue is typically resolved in 8-10 hours.
- There is no open dumping in Pune city since June, 2010 and all of the waste is processed scientifically. PMC plans to make Pune a zero garbage city by the end of this year.
- Biomethanation plants, plasma gasification and pyrolysis plants are in use in Pune.
- PMC's general body has passed a resolution according to which establishments which have come up after the year 2000 will not be granted building permission certificates unless they put in place a facility to scientifically dispose their solid waste onsite.
- PMC collects data for its Management Information System (MIS) to improve the attendance of its sweepers using mobile SMS and biometric attendance.
- ALERT-G has been put in place. This is a complaint redressal system based on citizens' participation.
- Ganesh Utsav is celebrated in an eco-friendly manner. Ganesh idols are immersed in specially constructed tanks to avoid river pollution. The offerings are collected separately and composted.
- Garden waste is collected separately using 15 trucks. This waste is shredded and composted. This compost is used in 115 gardens in Pune.
- Decentralized waste processing plants are located at societies/establishments which have come up after 2000. There are around 1,800 such projects which process around 27-30 tonnes of waste per day.
- The Hanjer plant, with a capacity of 1000 TPD for composting, RDF, pellets and bio-fuel, is located at Urali and Fursrunji.
- Ajinkya Biofert and Disha Waste Management are the vermin-composting and composting units.
- There are 18 decentralized biogas and mechanical composting units which process 80 tonnes of waste per day. These are 6 new plants coming up as well.
- Rochem Separation Systems has a plant with a capacity of 700 TPD, but is currently running at a capacity of 200-250 TPD.

- Two of the challenges in solid waste management relate to “Social Engineering” and “Technology Application”. The former deals with segregation, collection and transportation, while the later deals with processing and disposal. The aim of waste management is to “Reduce, Reuse, Recycle and Recover”.
- The various technology options for waste management are based on either bio-conversion or thermal conversion. Composting, vermi-composting and the generation of bio-gas come under bio-conversion. Thermal conversion technologies include pyrolysis and gasification, plasma pyrolysis, pelletization and the production of Refuse Derived Fuel (RDF).
- The Hanjer biotech plant in Pune has a capacity of 1000 tons per day. MSW is dried, crushed, screened and packed and into bricks to be used as a substitute to the conventional fossil fuels used in boilers. The wet fraction is converted into compost. Recyclables are converted into plastic ingots and other items. The leftover inert material is land-filled scientifically. This Refuse Derived Fuel technology is suitable for Indian garbage, which is heterogeneous and it reduces the need for land-filling. Emissions from the use of RDF have less NO_x, SO_x, CO and CO₂ compared to emissions from the use of coal. Additionally, bio-fertiliser and fly ash are useful by-products. However, this technology is the least suitable for high moisture content, low calorific value and chlorinated waste. Auxiliary fuel support may be required if the moisture/inert content of the waste is too high. There are high capital and O&M costs and skilled personnel are required. The overall efficiency for small power stations is low.
- “Gasification” is a process where waste is deposited in a closed container and burnt up at temperatures higher than 700 °C in the absence of oxygen. This results in the formation of “Syngas” which is mainly a mixture of Carbon Monoxide and Hydrogen. Syngas can be used to generate electricity. Pune’s Rochem Separations plant which treats MSW and generates electricity is the first of its kind in India. It has a capacity of 700 TPD but is operating at a capacity of 250 TPD currently and is generating about 2.5 MW of electricity per day. At full capacity it can generate up to 10 MW. This plant takes up only 10,000 square meters. Waste is disposed within 48 hours and there is less inert material after gasification is carried out. If the plant would run at full capacity, it would only leave 30 MT per day of fly ash to be disposed. A unique advantage of the Concord Blue

technology used in this plant is that the input and output can be changed depending on the market forces affecting the sale of high quality, high energy value Syngas, hydrogen, electricity and bio-char (which can be used as a fertiliser). However, the capital and O&M costs associated with this technology are very high – the 700 TPD capacity Rochem plant in Pune required an investment of almost Rs 150 crore. Apart from this, skilled personnel are required to operate the plant. The tariff rate for selling the electricity generated has not been finalised. Net energy recovery may suffer in case the waste has high moisture content and the high viscosity of pyrolysis oil makes its transportation and burning problematic.

- 40-45% urban solid waste is organic and can be easily treated by anaerobic digestion. The process of biomethanation produces methane and carbon dioxide rich biogas suitable for energy production. The nutrient-rich solids left after digestion can be used as a fertilizer. A 5 TPD capacity biomethanation plant requires 600 square meters of land, 5 cubic meters of water a day and 40 kWh of electricity per day. This can produce 250-300 cubic meters of biogas a day along with 500 kg of manure, 7,500 liters of liquid manure. Pune currently has 16 such biomethanation plants and 6 more will be put in place by 2015. Biomethanation is unsuitable for waste with low organic content and it requires waste segregation in order to improve digestion efficiency.
- It has been estimated that the total CO₂ equivalent emissions could have been 5.58 times the present level of emissions if PMC had not installed the technologies currently in place to scientifically process MSW in Pune city.
- E-waste, construction debris and land availability for treatment and disposal of waste are important future concerns. Possible solutions include building and operating higher capacity projects, separate byelaws for MSW and debris, independent processing facilities for e-waste, providing incentives for recycling, decentralizing administrative power, encourage private and public participation, promoting employment opportunities in wealth creation through waste, creating a market for carbon credits, using technology to monitor progress at regular intervals and working with the state and central governments to overcome bureaucratic hurdles.
- The SWaCH model has saved more than Rs 15 crore per annum in waste handling costs and has facilitated the collection of recyclables amounting to 20% of MSW. It has also

prevented the emission of greenhouse gases amounting to 2,94,316 metric tonnes of carbon dioxide equivalent per annum.

Dr. Suneel Pandey, Fellow, The Energy and Resources Institute (TERI)

- The CPCB in 2012-13 estimated that 62 million tonnes of solid waste is generated per annum in India. Solid waste generation is considered largely an urban phenomenon. Cities are considered to be the engines of growth but are witness to deteriorating urban services including MSWM. The per capita utilization of resources is much higher in urban areas than in rural areas, which is a cause for concern because resources are finite and cannot be replenished at the same rate as they are being used. Uncontrolled disposal of MSW is not only a source of environmental pollution but it also contributes to GHG emissions. Mumbai, Ahmedabad and Delhi have been struggling with the problem of landfill gas. Increasing waste generation will lead to increasing costs of waste management.
- CPCB 2005-06 data for all major state capitals in the country indicates that there is a huge variation in the composition of MSW across the country owing to the variation in climatic conditions. The proportion of compostable waste varies between 30 and 55 per cent, the recyclable material which reaches primary collection centres accounts for 5-15 per cent. Inert material, including construction and demolition debris, constitutes 40-55 per cent. The carbon-nitrogen ratio ranges from 14 to 53. This is important because compost with a carbon-nitrogen ratio higher than 25 indicates that it has high nutrient quality. Moisture content shows high variation (ranging from 17 to 65 per cent) but on an average, the moisture content of MSW in India is 45-50 per cent. Calorific value ranges from 520 to 3766 kilocalories per kg, but on an average it is 800-1200 kilocalories per kg.
- The recyclable content in MSW is lower in India than in developed countries because a lot of recyclable material is picked up by waste pickers and *kabadiwalas* and is sent for recycling separately. As a result, India reports a high rate of recycling (about 70%), though most of this waste is recycled in the informal sector.

- Construction and demolition debris is currently being disposed on land, but pilot projects in some countries show that this debris can be effectively recycled and that there is no need to send this waste to landfills.
- High moisture content and low calorific value of organic fraction of Indian MSW makes it more amenable to biochemical conversion. Technologies which have shown some success in developing countries fall into two categories: (i) bio-chemical conversion such as windrow composting, in-vessel composting, vermi-composting and anaerobic digestion and (ii) thermal processing such as incineration/cement kilns, use of RDF/fluff for energy generation, pyrolysis/gasification and landfilling while harvesting landfill gas. The use of plasma torch technology is quite expensive, making it commercially unviable for now.
- In order to produce RDF via incineration, MSW must first be dried and segregated. If the initial calorific value of the waste is low, then supplementary fuel can be added. Pelletisation/densification of the processed fuel is optional. Incineration produces power, flue gas, ash and heat (which can be used for heating in colder countries). Incineration is most suitable for high calorific value waste; the process produces relatively less noise and odour and requires only a small amount of land. Incineration has not been successful so far because Indian MSW has a lot of inert material, low calorific value and high moisture content which makes this technology too expensive to use. Incineration plants also have high capital and O&M costs and their functioning requires skilled personnel. The low heating value of Indian MSW is not ideal for energy recovery. Additionally, if waste contains toxic metals/PVC, incineration leads to increased air emissions.
- An alternative to incineration would be to use waste which is amenable to combustion as a fuel in cement kilns. Anything which has a calorific value and is not amenable to biochemical conversion (for example, plastics, wood, paper, rags and leather) can be shredded and homogenized for use as fuel in a cement kiln. This would reduce the need for traditional fuel while dealing with waste in the process. Since cement kilns operate under alkaline conditions, any acidic gases which come out are scrubbed within the cement kiln itself. However, waste with high chloride content is not good for the cement and the distance over which waste has to be transported is also a limiting factor. Cement manufacturers feel that transporting waste more than 100 km makes its use a fuel

unviable for them. A cement kiln in Tamil Nadu is currently processing waste tires, agricultural residue and MSW and using it as fuel in order to avoid using traditional fuel and to reduce GHG emissions.

- The process of producing RDF is similar to that of incineration. The only difference is that the processed waste in Vijayawada and Hyderabad is put through a boiler instead of an incinerator, thereby producing steam which is made to pass through turbines to produce power.
- Pelletisation/densification of waste increases the cost of RDF generation. If the power plant is close to the RDF unit, then fluff can be used instead of pellets to generate power at a lower cost.
- Once RDF is produced, a calorific value of 3000-3500 kCal/kg can be achieved. RDF pellets have high energy content and are easy to transport and store. Disadvantages include high energy consumption for crushing and drying and decreasing efficiency as the inorganic content increases. Additionally, high rainfall is not conducive to the production of RDF because drying the waste becomes costly. If the waste contains some toxic or acidic material, then the gas released on burning the RDF may need to be cleaned up.
- When waste is gasified at a controlled temperature, the gas can be used to run gas engines or as fuel in industrial processes. Bio-mass or coal-based gasifiers have been used successfully in some countries. Ceramic tile production units near Bhavnagar in Gujarat use gasifiers based on coal. The use of gasifiers as opposed to CNG enables them to produce at half the cost and to remain competitive in spite of low cost tile production in China.
- Gasification is suitable for waste with high calorific value (paper, plastics, wood), produces relatively less noise and odour and requires only a small area of land. High moisture content, however, can be a problem. This technology has not yet been commercialized.
- Where there are large landfills which contain organic waste, landfill gas can be extracted (for example in Gorai). This gas can be used for power generation or for low-value cooking applications. The landfill can be closed after harvesting the gas. However, when landfills are uncontrolled, methane gas escapes easily, which reduces the profitability of

extracting landfill gas. Landfill gas extraction also requires significant landfill infrastructure, very high volumes of waste and large land area.

- Some countries in Europe and the US are promoting bio-reactor landfills with gas extraction. The idea is to achieve rapid degradation of organic waste by re-circulating water and leachate through the landfill so that the bio-chemical reactions taking place can be hastened and the amount of gas which could be produced in 10 years may be produced in 4-5 years instead. The landfill can then be scientifically sealed much faster. The main disadvantage is that this process requires waste with a high organic content to make it cost effective. Also, there is limited technical experience for this and the costs of putting it in place would be very high in developing countries.
- Policies and regulations in Europe and some Asian countries including Japan and Korea indicate that these countries are trying to avoid creating more landfills because the availability of land is becoming a problem and the distances over which waste must be transported are increasing. The MSW Rules in India also prohibit the disposal of organics and recyclables in landfills. Therefore, we must look to maximize recovery through recycling and minimize the amount of waste we send to landfills.
- Some of the insights from MSW-to-energy projects in India and abroad are that the information on processes is limited by secrecy claims, there is no large-scale implementation experience for most new cutting-edge technologies, waste statistics and data are poor and extrapolations are dubious. Additionally, advocates and experts sometimes tend to popularize unproven and inappropriate technologies and technology failures are seldom reported.
- TERI is currently estimating the carbon footprint for various activities of the PMC, including urban transportation, water, sanitation and solid waste management.

Dr. Sharad P. Kale, Professor, Homi Bhabha National Institute and Head, Technology Transfer & Collaboration Division, Bhabha Atomic Research Centre, Trombay

- It is important to look at situations from more than one angle. In the context of solid waste management, we must initiate a change in perspective whereby “waste” is seen as a “resource”.

- Matheran is now a plastic-free city. 200 street lights run on the electricity generated by processed waste. The municipality has earned an ISO certification for this project.
- Citizens in Cologne, Germany, segregate waste into 5 categories. A sanitary landfill is the last option for disposing waste. Segregated waste from the other 4 categories is re-processed completely. Most municipalities in Germany are effectively running biogas plants despite the cold climate.
- BARC charges Rs 25,000 for their biogas plant (also known as the “Nisargruna” plant) technology. There is also a charge of Rs 500 for processing. A plant with a capacity of 1 MTPD costs Rs 20 lakhs and its life is about 40 years.
- The Nisargruna plant can use organic raw materials such as kitchen waste, vegetable market waste, abattoir waste, discarded bones, cattle dung and ETP sludge. Garden waste (processed through a fungal digester) can also be used as a raw material. Plastic waste cannot be used as a raw material.
- It is very important to trap the methane generated from decomposing waste to avoid global warming. The Baddi plant has burnt 70,000 metric cubes of methane in their canteen, which helps save LPG. This has also shortened the payback period for the plant. The manure which is produced as a by-product is used in the fields surrounding the plant.
- The biogas plant in Baddi, Himachal Pradesh operates on the basis of the Nisargruna technology. Kitchen waste is first sorted (to remove plastic, metal etc.), weighed and then sent to a garbage crusher. The kitchen waste slurry is then sent to a pre-digester tank. A solar water heater maintains the optimal temperature to encourage the growth of bacteria in the tank. 1 litre of water must be added per kg of waste. The slurry is then piped to the main digester tank. The biogas generated in this tank is collected in a gas reservoir directly above it. The gas is then piped to a gas blower. This sends the biogas to the canteen. Once the gas is generated, the leftover slurry is piped to a manure pit. The water that remains is sent back to the water tank. The dried manure is rich in nitrogen, phosphorous, potassium and iron and is a very good fertiliser for plants. It also helps to retain more water in the soil. The two biogas stoves in the canteen run continuously for 12-15 hours a day. These biogas stoves generate more heat than LPG-based stoves do. The kitchen waste from the canteen is stored separately for use in the plant. ETP sludge can also be used as a raw material, but the biogas generated from this will be less.

Discussion

- There is no successful business model for selling/marketing RDF as of now. To produce power from RDF, it would be a good idea to process RDF in a decentralised manner and set up one centralized power generation unit. If the quality of the RDF can be maintained, the cost of power generation through RDF would be roughly Rs 10-12 crore per megawatt. It is a better idea to use RDF as fuel in industries (such as small-scale textile, dyeing and printing units) which have already invested in furnaces and boilers.
- If the quality of the RDF is suspect, it is best to use it in a cement kiln where acidic emissions will be scrubbed by the alkaline atmosphere within the kiln itself.
- Hilly areas are more vulnerable to pollution than plains. Inert material can be recycled into pavement blocks or bricks. Landfills should be the last resort, especially in hilly areas. IL&FS has a pilot project in Delhi under which 500 TPD of construction and demolition debris is recycled. They are working with BIS to put in place standards for recycling inert material into pavement blocks, bricks etc.
- There is no “best” technology which will work in all situations. The technology (or combination of technologies) to be used must be chosen and customized according to the characteristics of the place in question.
- Strong community participation is necessary to promote waste segregation at source.
- At higher altitudes and lower temperatures, the amount of biogas that can be generated by the Nisargruna plant decreases and might be just enough to run the plant itself. However, it is still a good idea to use biogas plants to treat solid waste scientifically instead of dumping it in landfills. Small biogas plants can be set up in the valleys of hilly areas.
- The Nisargruna plant generates biogas and manure. In Baddi, 30-40 kg of gas is produced every day and can be used immediately. 1 tonne of waste generates about 60 kg of manure which can be collected every 2-3 months. The manure is currently being packaged and sold for Rs 20 per kg. Manure can also be used in municipal gardens.
- Food waste, which is used as an input in the Nisargruna plant, contains very little H_2S and the resulting emission of sulphur-dioxide is very low. As a result, the CPCB does not have a problem with sanctioning biogas plants.

- It is a better idea to store biogas in cylinders only in relatively big plants. The bottling technology costs about Rs 60 lakhs. At least 20 tons of assured biodegradable waste at one place is needed to make this cost-effective. However, once biogas is produced for sale, there have been cases where people stopped supplying their waste for free. It is therefore very important to put in place waste agreements for 8-10 years before investing in this technology.
- The fact that drinking water is used in flush tanks is deplorable. If bathroom and kitchen water is oxidized with the help of a compressor for 24 hours, this water can be recycled and re-used for flushing.
- Biogas can be sent up to a distance of 1 km with the help of a blower.
- If waste is segregated into dry and wet waste before it is sent to the biogas plant, it can be inspected and sent for processing within 30 minutes so as to avoid leaving it in the open and attracting flies. This also helps to reduce the odour.
- The process of incinerating waste to produce electricity leads to the emission of toxins like dioxins which are inimical to the health of human beings and the environment. It also destroys precious minerals like calcium and magnesium, among others. Although segregation is not required for incineration, this process doesn't take advantage of the opportunity to recycle dry waste. Incineration would also exacerbate climate change through the release of methane from untreated waste which is twenty times more harmful for the atmosphere than carbon dioxide.
- The municipality of Zoetermeer in the Netherlands has a composting plant which processes 68,000 MT of waste in 21 days without creating a bad odour. The entire plant requires only 3-4 people to keep it running.

Ms Kanak Tiwari closed the session by thanking Captain Pathania, HIPA, all the session chairs, speakers and participants.