
Waste incineration for urban India: valuable contribution to sustainable MSWM or inappropriate high-tech solution affecting livelihoods and public health?

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Abstract: Urban India is facing huge challenges in terms of population growth and resultant infrastructural needs. Municipal solid waste management (MSWM) still remains a challenge for urban local bodies. Municipal solid waste (management and handling) rules, 2000 was a first step in India towards organising the system, but till date the systems are largely insufficient and/inefficient. Focus on the urban sector in India increased with the initiation of the JNNURM programme in 2005. The programme initiated changes in the MSWM sector, yet resultant improvements are still far from satisfactory. Waste incineration, though perceived as a suitable option for MSWM in India, has concerns related to its suitability to Indian conditions. This paper aims to contribute to the necessary academic and political discussion by summarising some relevant facts of the urban waste sector in India as per GIZ experience and by providing information about the experience and relevance of incineration in Germany and Europe.

Keywords: urbanisation; municipal solid waste; waste incineration; waste to energy; environmental standards; incineration in Germany; India.

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1 Urbanisation and municipal waste

India's economy is growing at a faster pace than ever before in the history of the country. With an average growth rate of more than 7% since the year 1997, the country is ranked as the 12th largest GDP in the world. Urban India is the major driving force of the country's economic growth contributing to more than 60% of the GDP. It is estimated that by 2030, urban India could generate 70% of net new jobs and contribute to more than 70% of the Indian GDP. India has experienced rapid increase in urban population in the past few decades. According to Census of India (2011), the urban population of India has increased from 25 million in 1901 to 377 million in 2011. This growth has been more pronounced after the '80s and it is estimated that by 2050 half the Indian population will live in cities.

With rapid urbanisation and change of lifestyles, MSW has become a pressing problem resulting in severe environmental deterioration and aesthetic concerns. The total waste production in urban India is estimated to be 115,000 MT/d (metric tonnes/day), which amounts to almost 50 million MT/a (metric tonnes/year). According to an assessment carried out by NEERI in 2005 in 59 selected class I and II cities (NEERI Report, 2005) where class I cities refer to those cities having at least 1,00,000 population including the metros, whereas cities having population of 50,000–1,00,000 belong to class II category. The per capita generation of waste in Indian cities ranges from 0.17 kg–0.62 kg/capita/day, depending on the size of the city as well as the socio economic profile of the population. The waste composition also depends on a wide range of factors such as food habits, cultural traditions, lifestyles, annual season, climate and income, etc. Table 1 gives an overview of the waste generation and characteristics across these 59 cities. The table shows that the range of compostable fraction in the waste is between 29–62%, while recyclables vary from 9 to 36 % of total waste. Calorific value as well as C/N ratio of the waste also varies across cities.

Table 1 Waste generation and its characteristics in Indian cities

Population in range (in million)	Average per capita waste generation (kg/capita/day)	Municipal solid waste characteristics			
		Compostable fraction (%)	Total recyclables (%)	C/N ratio	Calorific value (kcal/kg)
< 0.1	0.17–0.54	29–63	13.68–36.64	18–37	591–3,766
0.1–0.5	0.22–0.59	29–63	13.68–36.64	18–37	591–3,766
0.5–0.1	-	35–65	11–24	17–52	591–2,391
1.0–2.0	0.19–0.53	39–54	9–25	18–52	520–2,559
> 2.0	0.22–0.62	40–62	11–22	21–39	800–2,632

Source: NEERI Report (2005)

2 Legal framework and current status of MSWM in India

Growing concerns regarding unsuitable waste management resulted in numerous public interest litigations (PILs) prompting the Supreme Court of India, in 1996, to order the Ministry of Environment and Forests (MoEF), Government of India, to issue rules regarding MSW management and handling, initially only for all class I cities.

Four years later, in 2000, the MoEF notified the Municipal Solid Waste (Management and Handling) [MSW (M&H)] rules for all Indian cities. The rules contained directives for all ULBs to establish a proper system of waste management including a timeline for installation of waste processing and disposal facilities by end of 2003.

To improve the municipal solid waste management (MSWM) systems in the cities the following seven directives were given:

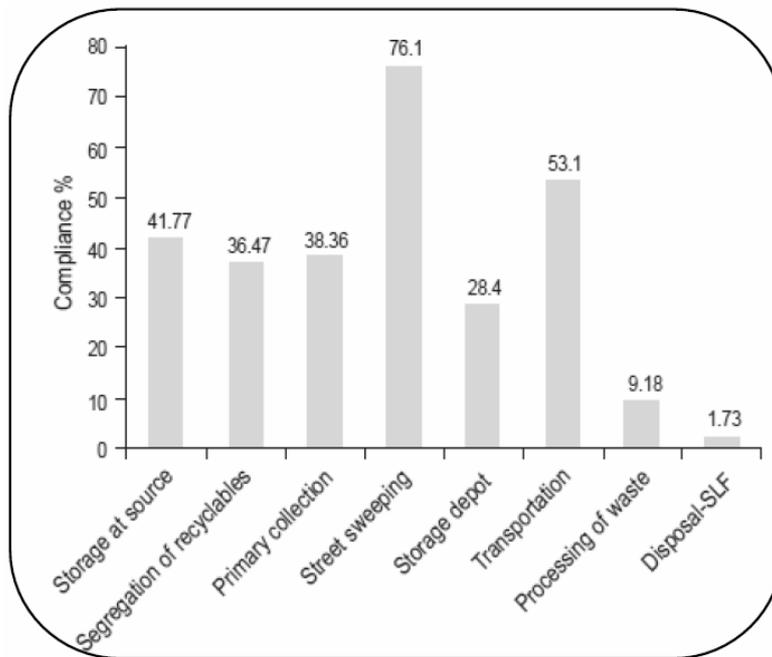
- prohibition of littering on the streets by ensuring storage of waste at source in two separate bins for biodegradable and non-biodegradable material respectively
- collection of segregated waste (biodegradable and non-biodegradable waste) from the doorstep (including slums and squatter areas), at pre-informed timings on a day-to-day basis using containerised tri-cycle/hand carts/pick up vans
- street sweeping covering all the residential and commercial areas on all the days of the year irrespective of Sundays and public holidays
- abolition of open waste storage depots and provision of covered containers or closed body waste storage depots
- transportation of waste in covered vehicles on a day to day basis
- treatment of biodegradable waste using composting or waste to energy technologies meeting the stipulated standards
- minimise the waste going to scientifically engineered landfills (SLFs) and dispose of only rejects from the treatment plants and inert material at the landfills as per the standards laid down in the rules.

Hence, though MSW (M&H) rules do not restrict any technology, the typical MSWM system in India as foreseen by the Rules would comprise of door to door collection of

segregated waste, transportation, treatment of organic waste (composting) and recycling of dry waste and (where appropriate) converting it into alternative fuels (refuse derived fuels/RDF), followed by scientific disposal of inerts on a scientifically constructed and operated landfill.

However, by end of 2003, the goal was still far away. A survey was conducted in 2004 in order to assess the nature of compliance to MSW (M&H) rules in urban areas and 128 class I cities responded. Figure 1 presents an overview of the study and the nature of compliance achieved. It is evident that the rules had not resulted in proper infrastructure development for scientific treatment and disposal of waste. Unavailability of funds and lack of proper understanding of the technology available at the ULB level were largely blamed for non-compliance of the rules.

Figure 1 Compliance to MSW (M&H) rules 2000



Source: Asnani (2006)

To address the issues related to urban governance and urban infrastructural development, Jawaharlal Nehru National Urban Renewal Mission (JNNURM) was launched by the Ministry of Urban Development (MoUD), Government of India, in 2005. The launch of this mission brought considerable change in the status of the ULBs as sufficient funds were allocated for many infrastructural projects with a special emphasis on MSWM.

The JNNURM also encouraged private sector involvement for innovative financing and technical up-gradation. As on May 2009, a total of INR 2090.52 crores INR (316 million Euros) had been sanctioned for 40 Indian cities to improve their solid waste management. Despite huge investments and the encouragement of the Central Government to invest in and adapt to the MSW (M&H) rules 2000, improvement in this sector is very slow. To further encourage the ULBs, the 12th Finance Commission of Government of India, had sanctioned additional 2,500 crores INR (415 million Euros) to

MoUD for strengthening the SWM schemes in ULBs and the 13th Finance Commission of the Government of India, recommended that of all grants to be given to the ULBs, 50% should be for SWM (2010–2015). According to a recent report published by Government of India on the National Implementation Plan for Persistent Organic Pollutants (PoPs) in 2011, 94% of the total municipal solid waste generated is still dumped, 4% is composted and only 2% recycled (Government of India, 2011).

In 2009, the MoUD initiated the process of service level benchmarking (SLB) by defining a set of performance parameters commonly understood and used by all stakeholders with respect to basic municipal services, namely water supply, sewerage, solid waste management and storm water drainage. The primary aim of the SLB initiative is to provide for:

- uniform set of indicators, definitions and calculation methodology to enable meaningful comparisons
- service benchmarks to create consensus on desired service standards
- data reliability grades to highlight and address issues of data quality
- self-reporting by urban local bodies (ULBs), as against consultants, to ensure ownership of data
- emphasis on performance improvement planning based on the SLB data generated.

Past experiences of GIZ reveal that limited data availability and reliability hampers the overall benchmarking exercise. The data inadequacies arise from lack of appropriate infrastructure and systems to measure and record data, the absence of requisite procedures for data monitoring and analysis as well as weak understanding of the concept of proper record keeping for performance monitoring and improvements.

Though benchmarking lays the foundation for performance improvements however currently, nationwide situation is as such that the process of SLBs still relies too much on theoretical waste figures and real time city level figures are not yet available in most of the cases.

3 RDF in India: framework and status

Environmental improvements in solid waste management are far from being satisfactory in most urban areas and with increasing levels of awareness, citizens are demanding better services. A major obstacle is the absence of proper land use planning, which hampers the process of finding suitable sites for treatment and scientific disposal of waste.

Managing solid waste and providing basic services to the citizens has become a huge concern which has triggered discussions regarding waste as a resource in general and waste to energy concepts in particular. Waste incineration, as one form of various waste-to-energy concepts, is being increasingly perceived by many stakeholders as a suitable option for MSWM in India.

Before we come to upcoming waste incineration projects in India it is necessary to understand the current role of RDF in MSWM in India.

As per GIZ experience, cities and towns in India can be broadly put in four categories as far as RDF is concerned:

- *Category I* – comprises of the majority of small and medium towns where no proper system of solid waste management is in place. In these towns, waste is usually collected and transported to an open designated dumpsite.
- *Category II* – comprises of those cities where collection, transportation, processing and disposal systems are in place. The waste processing facility comprises of a processing unit with either a composting plant or RDF unit or both and a sanitary landfill for disposal of inerts (with or without external funding). However, due to high O&M costs/absence of suitable end users, the RDF unit gets shut down or lies defunct.
- *Category III* – in this category, a city runs on public private partnership (PPP) framework, wherein the city has a PPP partner having an integrated waste processing plant comprising of composting and RDF units. The PPP partner has tie-ups with end users and sells the RDF as an alternative fuel.
- *Category IV* – in this category too, a city runs on a PPP mode having an integrated waste processing plant comprising of composting and RDF units but here the PPP partner uses its RDF for pre-processing and in-house generation of power.

In all the above mentioned categories, the final emission from combustion of RDF as an alternative fuel would depend upon quality of waste segregation, processing methodologies as well as on the combustion efficiency and pollution abatement techniques as applied by the end-users.. There are about 25–30 operating RDF processing plants in India, with an installed capacity of about 3,395 TPD. The quantity and quality of RDF produced per tonne of MSW varies depending on the type of collection, sorting and treatment process. Little is known about the emissions resulting out of use of RDF as alternative fuel in various processes as environmental regulations for use of RDF in these processes is largely intransparent. Only in limited cases co-processing of sorted plastic from municipal solid waste in cement kilns is well documented and monitored on the basis of guidelines issued by CPCB on common hazardous waste incineration.

4 Waste incineration in India

Table 2 is a comparison of the existing MSW (M&H) rules 2000 with the standards existing in Germany/Europe. It is evident from the table that the current Indian standards are very low and toxic contaminants created by waste incineration, like dioxins and furans, heavy metals incl. mercury have not been considered at all in the current standards.

In past, waste-to-energy plants in India using urban wastes, have largely not been successful. Though reasons are not well documented, but main causes are improper data on quantity and quality of available waste, delinks between the plant operators and the respective ULB/overall MSWM system, lack of financial sustainability or improperly structured subsidies.

Table 2 Comparison of Indian standards with German/European standards

Contaminant	17. BImSchV ¹ (mg/m ³)	MSW rules 2000 ² (mg/M ³)
Org. subst. (C-total.)	10	-
CO	50	-
HCl	10	50
HF	1	-
SO ₂	50	100
NO _x	200	450
SPM	10	150
Dioxins and furans	0.1 ng TEQ	-
Hg	0.03	-
Cd, TI	0.05	-
Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn	0.5	-
Minimum temperature	850 centigrade	-
Retention time	More than 2 seconds	-
Reference value for flue gas oxygen content	11% by volume	-
Reference value for flue gas oxygen content for waste pyrolysis/gasification/waste oil	3% by volume	-

Source: Seventeenth Ordinance of the German Federal Immission Control Act (BMU, 2009), only daily means and MSW (M&H) Rules, 2000 MoEF, GoI

Currently there are five waste-to-Energy plants underway in order to utilise the MSW. All receive grants by the Ministry of New and Renewable Energy (MNRE) as per their programme on Energy Recovery from Municipal Waste. MNRE through this programme is aiming at achieving international emission standards for waste-to-energy plants in India. Following PILs and consequent Supreme Court orders the main purpose of the programme is to prove that waste-to-energy projects from urban wastes are feasible and meaningful in India. Some details of the plants funded by MNRE are given below:

- Delhi: Timarpur-Okhla Waste Management Co Pvt Ltd: an initiative of M/s Jindal ITF Ecopolis. The incineration plant commissioned since January 2012 and is foreseen to process 1,300 TPD. The processing plant will produce 450 TPD of RDF and generate 16 MW power. Performance data are not yet in the public domain.
- Delhi: Ghazipur – Of the 2,000 TPD of waste received at the landfill daily, the facility will process/incinerate 1,300 TPD to generate 433 TPD of RDF and 12 MW power. The project is under construction. The PPP operator is M/s ILFS.
- Bangalore: An 8 MW power plant is in the process of being set up in Bangalore. This initiative is carried out under a PPP framework between M/s Srinivasa Gayithri Resources Recovery Ltd and Bruhat Bangalore Mahanagar Palike (BBMP). The plant is not yet operational.
- Pune: A 10 MW gasification plant is being set up in Pune with funds from MNRE. The plant will need 700 TPD of waste for production of 10 MW of electricity. The plant is still in the construction stage.

- Hyderabad: A 11 MW power plant, which will utilise 1,000 TPD of MSW, is being installed in the Nalagonda district. The plant will produce RDF for in-house incineration and power generation. The plant is currently under construction.

As per MNRE all these plants receiving subsidies/funds are expected to meet international standards for Dioxins and Furans, while the remaining standards will be as specified by CPCB/SPCBs.

Private companies are also trying to experiment with waste incineration and power generation on their own. For e.g., in Kanpur where M/s A2Z Infrastructure Pvt Ltd has a PPP for MSWM with Kanpur Municipal Corporation. The company has constructed an integrated MSWM facility for handling 1,500 TPD of MSW. A 15 MW power plant has been constructed for utilisation of the RDF onsite. Status and performance data are not known to the authors.

5 Emission data and environmental monitoring capabilities in India

In 2011, MoEF published India's National Implementation Plan on PoPs (Government of India, 2011), which contains data on dioxin/furan emissions from waste incineration by use of emission factors, not real measurements, although the report mainly focuses on hazardous waste and industrial pollutants. As per this report incineration of MSW is still not practised in India. Emissions from hazardous waste and biomedical waste incinerators in India contribute to about 64% of the estimated dioxins/furans released into the air. In absolute figures this amounts to emissions of 1,812 g TEQs/annum PCDD/Fs pan India. The other major contributors are industrial sources like ferrous and non-ferrous metal products, heat and power generation plants, etc. Data on various combustion processes using RDF are not available.

The Central Pollution Control Board (CPCB) is executing a nation-wide programme for monitoring ambient air quality known as the National Air Quality Monitoring Programme (NAMP). The network consists of 342 monitoring stations covering 127 cities/towns in all 26 states and four union territories in the country. However, in the area of dioxins and furans, there is very little coordinated research at the national level and the National Implementation Plan has just begun to address the issue in a comprehensive manner.

The first work on dioxin emissions was initiated by the MoEF in consultation with the National Institute for Interdisciplinary Science and Technology (NIST), Trivandrum, during 2003–05 when emissions from medical waste incinerators were monitored. Following the ratification of the Stockholm Convention on POPs, agencies like CPCB and National Environmental Engineering Research Institute (NEERI) have initiated research on dioxins/furans. A few national laboratories and NGOs have also developed the skills for monitoring and analysis of dioxins/furans, but capacities for sampling and analysing emissions of PCDDs/Fs in flue gas of incineration processes are inadequate in India and State Pollution Control Boards (SPCBs) are largely unable to monitor these emissions due to lack of capacities. Capacities for measurements of other relevant pollutants such as heavy metals and the very toxic mercury may be slightly higher, but there is still scope for significant strengthening.

6 Contribution of waste to energy to the growing energy demand in India

The important role of energy for India's economic growth is well understood. The country's annual electricity generation capacity has increased in the last 20 years by about 120 GW, from about 66 GW in 1991 to over 100 GW in 2001 to over 200 GW installed capacity in 2012 (Central Electricity Authority, Ministry of Power, Government of India, 2011–2012). Although there has been a gradually increasing dependency on commercial fuels, a sizeable amount of the national energy requirement, especially in the rural household sector, continues to be met by non-commercial energy sources. The data from a study carried out by the MNRE suggest that by 2030 coal will remain a dominant source of fuel contributing to around 51% to the total primary energy supply, while the share of oil will be around 15%. The major challenge will be to keep pace with rising energy demands in order to provide enough energy supply to the nation. Despite efforts to enhance electricity production and diversify fuel mix, India still faces electricity as well as peak electricity consumption shortages of around 10% and 12% respectively, and a large section of the rural population still continues to lack access to clean and efficient energy fuels to meet their daily requirements. Urban areas, especially the second tier and smaller cities and towns are also increasingly facing a deficit in their daily electricity requirements.

India's growing energy deficit is making central and state governments keen on alternative and renewable energy sources. Waste to Energy is one of these alternative sources and there is growing interest in this area from both the central and state governments. According to the MNRE website (Ministry of New and Renewable Energy, 2010–2011) there exists a potential of about 1,700 MW from urban waste 1500 from MSW and 225 MW from sewage/sludge and about 1,300 MW from industrial waste. Provided the potential of energy from urban wastes is approximately in the range of 1,700 MW as estimated by MNRE. Assuming an efficiency factor of 30% for production of electricity, 1,700 MW generated from urban waste would account for approximately 0.42% of the current peak electricity consumption.

7 Role of the informal sector

The informal sector in India is very active in the field of waste management. It comprises of four kinds of players namely the big and small kabariwalas/junk dealers, collectors and the waste pickers/rag pickers. The small junk dealers buy recyclable or reusable waste from households, commercial or other establishments and send them for recycling through a well-established though not formally recognised route of collectors and big junk dealers. The waste pickers/rag pickers collect recyclable/reusable waste from the secondary or tertiary collection points or at the landfills and then sell to the junk dealer for a living.

The informal sector plays a major role in ensuring that 2 of the 3 Rs – reuse and recycle are taken care of. According to a study by an NGO in Delhi, waste produced in Delhi supports a population of approximately 100,000 waste pickers, who recover approximately 15–20% of usable materials by weight, such as metal, paper, cardboard and plastic from the city's waste every day. This sector drives the city's recycling efforts and saves civic agencies huge amounts of money. If the municipality paid minimum

wages to an equal number of employees for this work, it would cost Delhi at least Rupees 15 million every day (Chintan Environmental Research and Action Group, 2012). It is feared that this recycling and reuse of waste by the informal sector could suffer if the principles of 3R are not strictly adhered to by the different stakeholders that govern municipal waste management in India.

In Germany, the recycling sector is formalised and because of stringent laws following the principles of the waste management hierarchy, which gives priority to avoidance, reuse and material recycling over production of thermal energy of residual waste and disposal, more than 60% of the municipal solid waste in Germany is currently recycled and composted.

8 Policies, instruments and stakeholders

Following is a short overview of relevant policies, instruments and Government stakeholders in the municipal solid waste sector:

1 MoEF, GoI

- The MSW (M&H) rules, 2000 issued by MoEF under the Environment (Protection) Act, 1986, prescribes the manner/system in which the urban local authorities have to undertake collection, segregation, storage, transportation, processing and disposal of the municipal solid waste generated within their jurisdiction. The Rules are currently under revision.
- CPCB is the scientific and technical arm of MoEF, dealing with issues regarding pollution abatement, monitoring and enforcement of related environmental regulations. CPCB is also giving guidance to the SPCBs, who are directly responsible for enforcement of environmental regulations.

2 MoUD, GoI

- The JnNURM was initiated in response to the increasing pressure on urban infrastructure and basic services to the citizens by MoUD in 2005. This includes development of appropriate systems for solid waste management as one of its main objectives. Under JnNURM, GoI has supported 42 SWM projects worth USD 500 million (INR 2,750 crore at 1 USD = 55 INR) for establishing municipal waste management systems in 42 cities, as per the MSW(M&H) rules.
- The National Urban Sanitation Policy (NUSP) was prepared by MoUD in 2008 to improve the sanitation situation in the urban areas. The policy primarily focusses on city wide affordable sanitation facilities including SWM. Key instruments are city sanitation plans (CSPs) and state sanitation strategies (SSSs).
- The National Mission on Sustainable Habitat (NMSH) launched in 2010 is one of the eight missions under the National Action Plan on Climate Change (NAPCC). The NMSH seeks to promote improvements in energy efficiency, better urban planning, improved management of solid and liquid waste and overall improved ability of habitats to adapt to climate change through appropriate change in the legal and regulatory framework.

- The Central Public Health and Environmental Engineering Organization (CPHEEO), the technical arm of MoUD, has developed a manual on MSWM, which aims at assisting the decision makers and technical personnel involved in solid waste management activities in the safe and hygienic handling and disposal of MSW generated in urban areas in India.
- 3 MNRE, GoI – MNRE encourages renewable energy sources in general and supports waste to energy projects with an objective to create conducive environment and to develop, demonstrate and disseminate utilisation of urban waste for energy recovery. The program on energy recovery from municipal solid waste is a part of the National Master Plan for Development of Waste to Energy in India. The main objective is to accelerate the installation of energy recovery projects from industrial/municipal waste with a view to harness the available potential. Financial incentives are being provided for eligible waste to energy projects under NMP at 50% of project costs, subject to an upper limit of Rs. 3 crores. Incentives can also be provided to ULBs, State Nodal Agencies for promotion, coordinating and monitoring of projects. The five projects listed in the earlier section have been funded as part of this programme.

9 The German/European experience

Today, there are about 69 municipal solid waste incinerators (MSWIs) in Germany, treating residual waste to the tune of 18 Mio tones/a out of a total of 46 Mio t/a, which is about 39 % of the total MSW generation in Germany without any negative environmental or public health impacts. But this was not always so.

The first waste incineration plant in Germany was built in 1894/95 in the wake of the last major cholera outbreak in Hamburg. The twenties and thirties of the 20th century saw a significant development of the incineration technology as well as the first use of an electrostatic precipitator for flue gas clean-up. Technical advances allowed fully automated plant operations with continuous waste feed to the combustion chamber and continuous slag removal. The technology developed for these second-generation plants constituted the basis for the modern waste incinerators.

Further development of the technology – from the point of view of environmental performance – led to the ‘MSWI of the modern age’ equipped with fully developed firing technology and powerful flue gas cleaning systems (third generation), a development that was accelerated in particular by the stringent emission control standards of the Waste Incinerator Ordinance (17. BImSchV) passed in 1990 (Seventeenth Ordinance of the German Federal Immission Control Act BMU, 2009). The late ‘90s of the last century saw the advent of the fourth-generation plants characterised by slimmed yet equally efficient flue gas cleaning systems. These days, waste incineration is on its way towards the fifth plant generation and the development of technology has not reached its end by far. This applies in particular to energy efficiency improvements, while first priority remains the final disposal of waste and not energy recovery.

This impressive evolution towards environmentally sound waste incineration would not have happened without the fierce resistance of the public against waste incineration in the 80’s in Germany. With growing public awareness on environmental issues, waste incinerators were increasingly viewed as a source of critical air pollutants and became the subject of controversial public debate. As measurement and analysis methods were being

continuously further refined, pollutant groups like dioxins and furans that had hitherto been largely unknown and were to go down in history as a synonym for major industrial accidents were also identified in incinerator flue gases. And indeed, concentrations of dioxins and furans in the flue gas of MSWIs were found to be as high as 400 ng toxicity equivalents (TEQs)/m³ flue gas, which is 4,000 times more than the current internationally accepted standard of 0.1 ng TEQs/m³ flue gas and more than 8,000 times higher than the current real emissions of Germany MSWIs.

In view of the dramatically increasing waste volumes produced by the affluent society, MSWIs – at that time termed ‘poison spewers’ – epitomised the uncontrolled growth of consumption in the industrial society at the expense of the environment. Prompted by fears over dioxin emissions, the citizens started to take on waste incinerators. And they did so with success: public opposition to pollutant emissions from waste incinerators fuelled the further development of the firing, air pollution control and monitoring technologies, thus reducing pollutant emissions and improving the environmental compatibility of the plants.

At the same time, the technical and political discourse brought the German Waste Management Act of 1986, introducing the waste management hierarchy ‘prevention before recycling before disposal’, thereby paving the way for a more environmentally sound waste disposal strategy. Moreover, the introduction of extremely stringent pollution standards for waste incinerators would not have been politically feasible, if landfilling of untreated waste would have been regarded as an alternative. But, following long term environmental concerns due to landfilling, mainly related to water pollution and scarcity of land, the German Government decided in 1984 to practically ban landfilling of municipal waste by the year 2005.

Finally in the year 1990, Ordinance No. 17 on the Implementation of the Federal Emission Control Act governing Incineration Plants for Waste and similar Combustible Substances (17. BImSchV) took effect, tightening emissions from MSWIs. This Ordinance established the most stringent emission limits worldwide, notably for carcinogenic and toxic substances such as dioxins and heavy metals. Within a given transition period all existing waste incinerators had to be retrofitted with sophisticated flue gas cleaning technology or else they had to be closed down. New facilities had to meet the prescribed emission limits from day one of their operation. In addition, 17. BImSchV imposed strict requirements for emission monitoring. These days, virtually all pollutant emissions – including dust and heavy metals such as mercury (Hg) – are continuously monitored. To ensure complete pollutant destruction, the 17. BImSchV prescribes minimum temperatures and residence times for the combustion products in the combustion zone. These requirements have remained in force up to the present day, in both the German and the European legislation.

Since 2000, the EU Waste Incineration Directive has been in force (RL2000/76/EEC). The basis for this Directive was the 17. BImSchV of 1990. The transposition of this Directive into the national law led to the amendment of 17. BImSchV in August 2003. As a result, emission limits have been further tightened and more stringent requirements apply to the co-incineration of waste in industrial firing systems such as cement kilns or coal-fired power plants.

Since 1996, all German waste incinerators have been operating in compliance with the rigid emission levels mandated by 17. BImSchV and dioxin and furan concentrations are limited to 0.1 nanograms TEQs per cubic meter of flue gas. In a similar way, emission limits for heavy metals, dusts and acid gases such as sulphur dioxide, hydrogen

chloride and others have been severely tightened so that emissions of these components are these days no longer health-relevant.

Without waste incinerators, the ambient air pollutant levels would have been much higher than with waste incinerators as electricity and heat generated in MSWIs substitute fossil energy sources in conventional (heat) power plants which typically release higher specific pollutant levels than waste incinerators. For the carcinogenic substances arsenic, cadmium, nickel, benzo(a)pyrene, benzene, PCB and dioxins/furans, for instance, the MSWIs operated in Germany deliver a credit of around 3 tonnes of arsenic equivalents per annum. In other words, if the energy produced by MSWIs were generated by conventional coal-fired power plants, the ambient air concentration of these pollutants would increase by 3 tonnes.

As a result of the German strategy, which follows the internationally accepted waste hierarchy, more than 60% of the municipal solid waste is currently recycled, e.g., biowaste, paper, glass or packaging waste. Landfilling of untreated municipal solid waste has been banned since 1 June 2005. These days, approx. 18 million t/a of waste is thermally treated in just under 70 MSWIs. Due to stringent emission control standards, dioxin, dust and heavy metals emissions from waste incineration are no longer an issue, in spite of the fact that waste incineration capacity has more than doubled since 1985.

Very recently the 'Circular Economy' law – 'Kreislaufwirtschaftsgesetz' has been amended and has entered into effect on June 1st, 2012 in Germany. It defines objectives, for example on recycling of 65% of all municipal solid waste and material recovery of 70% of all construction and demolition waste until 2020. From 2015 on, separate collection of biowaste, waste paper, glass and plastics will be mandatory in order to improve recycling quota. Other new provisions have been made regarding residues and the 'end of waste' status for certain materials, the ranking of different valorisation processes, or on programmes for waste minimisation.

10 Conclusions

In principle waste incineration of residual municipal solid waste that is properly designed and operated can be a valuable contribution to a sustainable waste management strategy, which clearly gives priority to avoidance and material recycling. Making optimal use of the energy content of the incinerated waste is a must and requires integrated spatial planning, as the thermal energy needs are to be utilised rather locally.

Waste incineration, like any other efficiently operated combustion process must contribute to the growing energy demand, yet its net contribution to the energy demand is rather low. Though there is still a considerable scope for improvement but can never be the major solution. Estimates by MNRE indicate a potential of approximately 0.42% of the current peak energy consumption generated from W2E projects at an all India level by 2030.

Given high levels of material recycling the potential of waste incineration to reduce GHG emissions of the waste sector is much higher than its contribution to the power sector because of its potential to avoid methane emissions from landfills or dumps.

The wide acceptance of waste incineration in Germany and the European Union is based largely on transparency and data availability with regard to emission levels, environment and public health impacts as well as economic and social outcomes. Acceptance has not come over night but is rather a continuous process, build into every

consent procedure needed for any major change in the plants along with considerable R&D activities.

This leads to the following recommendations:

10.1 Data transparency and quality

There is a need to improve the data quality in the waste sector in India and to make it fully transparent. The only comprehensive study focusing on waste quantities and qualities of waste in the urban sector in India stems from 1995. Reliable, nationwide data on calorific values as well as content of toxic materials in the municipal waste streams is not available. Looking at the change processes in the urban sector in India during the last 2 decades, both in growth and change in consumption patterns, strategic decisions should be based on detailed data across all tiers of urban local bodies. Scattered, mainly project oriented data is available, but is usually not in the public domain and also not very useful when it comes to taking decisions at the national level.

The SLB process, initiated by MoUD, focuses on data quality and usage of this tool for effective monitoring systems for performance delivery. This process needs to be further strengthened through capacity building and provision of adequate staff at the state level and with continuous handholding at the ULB level.

10.2 Strengthening of monitoring and regulatory capacities

Waste incineration, like any other combustion process, needs to be carefully monitored. Currently, combustion processes, which use fractions of MSW to substitute fuel (RDF) are often not properly monitored, leading to environmental pollution including emissions of dioxins and furans. Same is true for open burning of waste, which is still a common practice. Given the current practice of channelising RDF into numerous combustion processes and open burning of waste leading to high emissions and occupational health hazards, there is a need for immediate legal and practical action on the subject (e.g., introduction of binding quality standards for RDF).

While a lot can be achieved by proper monitoring and enforcement by the respective SPCBs and by initially focusing on the two main parameters, namely CO and dust which indicate complete combustion, it is essential to take a stock of accredited specialised institutions able to conduct routine measurements of normal and highly toxic pollutants in order to prove regular compliance with set standards, in cases where continuous monitoring is not possible. In absence of clear standards set in this regard by GoI, which has resulted in keeping demand for emission measurements low, the market forces in India have not yet built the needed capacities. Universities, research institutions, international exchange and publicly funded R&D activities will be needed to support this sector. Accredited firms, capable to deliver high quality environmental monitoring needs should be encouraged and capacities of the regulatory bodies (SPCBs) also need to be strengthened.

10.3 Documentation of data, approaches and lessons learned from upcoming projects

As mentioned above, there are many stakeholders that have data related to their upcoming MSW incinerators/RDF plants in India. It is necessary to initiate a

comprehensive data base on these projects with regard to their financial viability as well as expected environmental and social impacts. This should not be limited to secondary data but should also include some primary data collection in order to learn from these pilot projects in the sector.

10.4 Joint agenda of GoI, States, cities, academia, NGOs and private sector

MoEF has begun the process of revising the MSW rules, 2000 keeping in mind the current scenario of MSW management in India, the land scarcity and potential adverse long term effects of landfilling in terms of environment/climate and related costs and the already upcoming incineration projects. While it will be necessary to orient future permissible emissions for incineration of MSW towards internationally accepted standards, there is a need for a MSWM policy to emerge for further guidance in the sector. Such a policy should clearly adopt the internationally accepted waste hierarchy, giving priority to the prevention and reuse followed by material recycling, energy recovery and disposal.

Through this policy, the various aspects and competencies of municipal waste management in various ministries (MoEF, MoUD, MNRE, etc.) need to be synergised and converged.

The NUSP, which had been announced in 2009, besides of sewerage and storm water management, is already aiming at improving municipal solid waste management. It mandates states and cities to come up with SSSs and CSPs. While the CSPs are comprehensive sector planning documents in line with the city development plans (CDPs); the SSSs needs to focus on support and guidance by the states for the sector. Forthcoming states have already started to look into their own MSWM strategy for the state which can be very much part of a larger SSS.

It is suggested to initiate an inter-ministerial process on waste incineration as part of the ongoing review of the MSW rules under the guidance of MoEF, involving other stakeholders like central ministries, states, cities, NGOs, private sector and academia to chart a way forward. Results can be used as an input into a later process leading to a national waste management policy.

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