🏆 *reviewed paper*

Smart Meters for Accounting Smart Solid Waste Mangement for Smart Cities in India

Sanhita Bandyopadhyay

(Sanhita Bandyopadhyay, Environmental Planner, Ph.D Scholar, D-79, South City II, Gurgaon, bsanhita2@yahoo.co.in)

1 ABSTRACT

Rapid urbanization along with increases in population has led to the deterioration of physical environment in India. Effective Solid Waste Management is one of the major challenges faced by the local authorities. High volumes of waste generation, inefficient collection and transportation system and limited disposal options are continuously impacting the health, environment and quality of life in the area. A number of technologies are being proposed for management and disposal of garbage in general for different city or towns but so far no technology has been shortlisted as the one which would be viable not only from the environment angle but also in terms of the cost involved for unanimously in urban local body in India.

During the last century urban population of India increased ten folds from 27 million to 270 million. India produces 48.0 MT of MSW annually at present. Central Pollution Control Board, India (2009) said that by the year 2021, the urban population is expected to represent 41% of the overall population and subsequently MSW is expected to increase to 300 MT per year, by the year 2047 (490 g to 945 g per capita). Due to an increase in population and subsequently increase in waste generation, landfills could become a major source of atmospheric pollution.

Cities which are not clean do not exhibit a smart character. Cities which are clean are perceived to be smart, providing a healthier environment and a better quality of life. Therefore, they attract people – both people who want to live and work in the city and those who want to invest in the city.

It is in this context that the Government has decided on developing 100 “Smart Cities” in the country. It includes one satellite city of each of the cities with a population of 4 million people or more comprises of 9 cities, most of the cities in the population range of 1 – 4 million people about 35 out of 44 cities, all State/UT Capitals, even if they have a population of less than one million including17 cities, Cities of tourist, religious and economic importance not included 10 cities and Cities in the 0.2 to 1.0 million population ranging 25 cities.

Smart city meters segregation of recyclable and non-recyclable waste as well as wet and dry waste at the source so that there can be 100 percent recycling of solid waste. Appropriate technology should be adopted for treatment of waste at decentralized locations, put in place an effective collection and disposal system, encourage use of products based on recycling of solid waste especially – power, compost, building material (based on cycling of debris & construction materials).

Now the question is how to make it smart mechanism. What are the parameters to account the smartness of solid waste mnagement process including smart storage, smart collection mechanism, smart transportation, smart process and smart disposal. This paper has attempted to frame out web based automatic database mechanism to account the the process metering of solid waste mangement for 100 smart cities in India.

2 INTRODUCTION

Research on smart cities has been coinaged to Indian vision by Govt and many applications have been framed. Typical example includes smart transport to find the best route taking into account the current traffic conditions in mega polis and metro polis. All these applications are a step towards the realisation of a complete smart city. Another field of interest that should be made smart concerns the waste management. All cities, regardless their size, their geographical location or their economic level, spend huge amount of money every year for waste collection rather than its mangement. The number of bins located in the streets and the number of vehicles used to empty them are generally estimated based on the number of citizens, but the resulting estimation is sometimes either too high or too low or not accounted the feasibility of waste collection, further transportation, processing and disposal. The natural consequence is the provision of poor service or to incur in high costs (e.g. the cost of fuel for too many trucks for ultimate disosal). Furthermore, the collection of waste, regardless the type of material (recycling or unsorted), is typically fixed without taking into account the actual state of the level of fullness for each bin. The result is the collection of semi-empty bins or the trash accumulation degrading conditions of hygiene of the city (C. Vincenezo & V. Daniela, 2014, FRUCT Conference Proceedings). Their paper has framed the architecture for smart

ISBN: 978-3-9503110-8-2 (CD-ROM); ISBN: 978-3-9503110-9-9 (Print)
Editors: M. SCHRENK, V. V. POPOVICH, P. ZEILE, P. ELISEI, C. BEYER

collection of waste, monitoring the fullness of bins through the use of various types of sensors, was assumed to help to achieve a more efficient system and defined "smart waste system management". But the question how much Indian citizen is pro to react with this smart system. Moreover, in a smart city context, it is also important to allow users to interact with ubiquitous information produced by the city, anytime and from any device. This paper is stating the framework to propose a solution for smart metering for Smart visionary cities of India.

3 IDENTIFIED SMART CITIES IN INDIA

There are various agencies have defined the term 'SMART City'.

The UK Department of Business, Innovation and Skills considers smart cities a process rather than as a static outcome, in which increased citizen engagement, hard infrastructure, social capital and digital technologies make cities more liveable, resilient and better able to respond to challenges.

The British Standards Institute defines it as "the effective integration of physical, digital and human systems in the built environment to deliver sustainable, prosperous and inclusive future of its citizens".

IBM defines a smart city as "one that makes optimal use of all the interconnected information available today to better understand and control its operations and optimize the use of limited resources".

CISCO defines smart cities as those" who adopt scalable solutions that take advantage of information and communications technology (ICT) it increase efficiencies, reduce costs and enhance the quality of life".

Institutional Infrastructure (including Governance), Physical Infrastructure, Social Infrastructure and Economic Infrastructure constitute the four pillars on which a city rests as Smart City. The centre of attention for each of these pillars is the citizen. In other words a Smart City works towards ensuring the best for its entire people, regardless of social status, age, income levels, gender, etc.

The rapid urbanization of indian cities has resulted in unplanned development and urban sprawl. Most of the cities in our country are marred by congested CBDs and deteriorating city core.It is in this context that the Government of India has decided on developing 100 "Smart Cities" in the country. It includes

(1) One satellite city of each of the cities with a population of 4 million people or more (9 cities)

(2) Most of the cities in the population range of 1 – 4 million people(about 35 out of 44 cities)

(3) All State/UT Capitals, even if they have a population of less than one million (17 cities)

(4) Cities of tourist, religious and economic importance not included in above (10 cities)

(5) Cities in the 0.2 to 1.0 million population range (25 cities)

Out of four pillar Physical Infrastructure Pillar of smart city refers to its stock of cost-efficient and intelligent physical infrastructure such as the urban mobility system, the housing stock, the energy system, the water supply system, sewerage system, sanitation facilities, solid waste management system, drainage system, etc. which are all integrated through the use of technology.

Cities which are not clean do not exhibit a smart character. Cities which are clean are perceived to be smart, providing a healthier environment and a better quality of life. Therefore, they attract people – both people who want to live and work in the city and those who want to invest in the city.

4 SOLID WASTE MANAGEMENT SCENARIO OF INDIAN CITIES

Indian cities are facing many issues with regard to waste management practices, which include:

- Absence of segregation of waste at source.
- Lack of technical expertise and appropriate institutional arrangement.
- Lack of proper collection, segregation, transportation, treatment and disposal system.

It is estimated that solid waste generation in small, medium and large cities and towns is about 0.1 kg, 0.3 – 0.4 kg and 0.5 kg per capita per day respectively (CPHEEO Manual). CPCB in assistance with NEERI has survey records of waste generation and characteristics for 59 cities (35 Metro Cities and 25 State Capitals: 2004-05) of the country and the characterization of waste which can be used for composting or for incineration practice. MSW characteristics indicate the effect of urbanization and development in India. In

urban areas, the major fraction of MSW is compostable materials (40–60%) and inert (30–50%) as referred in following table. Per capita generation rate is high in some states (Gujrat, Delhi and Tamil Nadu) and cities (Madras, Kanpur, Lucknow and Ahmedabad). This may be due to the high living standards, the rapid economic growth and the high level of urbanization in the states and cities. However, the per capita generation rate is observed to below in other states (Meghalaya, Assam, Manipur and Tripura) and cities (Nagpur, Pune and Indore).

Population range (in million)	No. of cities surveyed	paper	Rubber, leather and synthetics	Glass	Metal	Compostable matter	Inert material
0.1-0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5-1.0	15	2.95	0.73	0.56	0.32	40.04	48.38
1.0-2.0	9	4.71	0.71	0.46	0.49	38.95	44.73
2.0-5.0	3	3.18	0.48	0.48	0.59	56.57	49.07
5.0 and above	4	6.43	0.28	0.94	0.8	30.84	53.9

Table 1.1: Physical characteristics of MSW in Indian cities population wise (weight basis %). Source: NEERI report strategy paper on SWM in India, August 1995.

In urban areas, the major fraction of MSW is compostable materials (40–60%) and inerts (30–50%). The relative percentage of organic waste in MSW is generally increasing with the decreasing socio-economic status; so rural households generate more organic waste than urban households. It has been noticed that the physical and chemical characteristics of MSW change with population density. With the increasing of population size calorific value is less in waste material where as C/N ratio is almost same in all types of cities in India as stated following table.

Population range (in millions)	Nitrogen as total Nitrogen	Phosphorus as P_2O_5	Potassium as K_2O	C/N Ratio	Calorific value kcal/kg
0.1-0.5	0.71	0.63	0.83	30.94	1009.89
0.5-1.0	0.66	0.56	0.69	21.13	900.61
1.0-2.0	0.64	0.82	0.72	23.64	980.05
2.0-5.0	0.56	0.69	0.78	22.45	907.18
5.0 and above	0.56	0.52	0.52	30.11	800.70

Table 1. 2: Chemical characteristics of MSW in Indian cities population wise in percentage (on weight basis). Source: NEERI report strategy paper on SWM in India, August 1995.

Storage of MSW at the source is substantially lacking in most of the urban areas. The bins are common for both decomposable and non-decomposable waste (no segregation of waste is performed), and the waste is disposed at a communal disposal center. Storage bins can be classified as movable bins and fixed bins. The movable bins are flexible in transportation but lacking in durability, while the fixed bins are more durable but their positions cannot be changed once they have been constructed (Nema, 2004). The collection efficiency ranges between 70 to 90% in major cities whereas in several smaller cities the collection efficiency is below 60% (ref in table 1.3). Street sweeping is another type of collection method for the collection of street litter; many cities spend 30-50 % of their solid waste budgets on street cleansing (the Expert Committee, 2000). Most of the cities are unable to provide waste collection services to all parts of the city. Generally, overcrowded low-income settlements do not have MSW collection and disposal services. The reason is that these settlements are often illegal and the inhabitants are unwilling or unable to pay for the services. They throw away the waste near or around their houses at different times, which make the collection and transportation of waste very difficult in these areas.

The recycling sector in India has been in operation since the 1960's and while only a fraction of the total plastic waste is being recycled in most western countries (APME, 1995), around 75% of the plastic wastes are recycled in India (Haque, 1998). Rag pickers mainly carry out the recycling process in India and they play a vital role in the economy of solid waste recycling process (Aggarwal, et al 2005).

However, the rag pickers do not have sufficient protection and are exposed to waste and sometimes even the hazardous waste present in MSW. A study carried out in 2003 has shown that 75 percent rag pickers have upper and lower respiratory symptoms (Bhattacharya, 2005). Even the quality of the successively recycled products in the informal sector in terms of their physical appearance, polymeric properties, health hazards (for the recyclers and users of such products involved) are in serious question (Haque, 2000).

Another aspect to be noted is that plastic carry bags do not figure in the list of priorities for rag pickers, because collecting them is not profitable. This is primarily because the rewards do not match the efforts

ISBN: 978-3-9503110-8-2 (CD-ROM); ISBN: 978-3-9503110-9-9 (Print)
Editors: M. SCHRENK, V. V. POPOVICH, P. ZEILE, P. ELISEI, C. BEYER

required for collection, and this leads to plastic bags continuing to pose a major threat to the environment (Narayan, 2001).

State	Per capita generation (g/cap/day	Per capita disposal (g/cap/day)	Collection efficiency (%)
India (sample average)	377	273	72
Andhra Pradesh	346	247	74
Bihar	411	242	59
Gujarat	297	182	61
Haryana	326	268	82
Karnataka	292	234	80
Kerala	246	201	82
Madhya Pradesh	229	167	73
Maharashtra	450	322	72
Orissa	301	184	61
Punjab	502	354	71
Rajasthan	516	322	62
Tamil Nadu	294	216	73
Uttar Pradesh	439	341	78
West Bengal	158	117	74

Table 1.3: Per capita generation, disposal and collection efficiency of MSW for Indian state. Source: Nema, 2004

In the process of rapid urbanization solid waste management from a low priority, localized issue to a pervasive social and environmental problem with risks to public health and environment. MSW management is constrained by institutional weakness; lack of proper funding, lack of proper management and operational systems, public apathy, lack of municipal will become financially self-sufficient through municipal taxation, etc. Disposal is the only favorable method to urban local body without any further action. Day by day increasing trend practice of dump to dump yard won't sustain the function. So there is a requirement of taking integrated policy and technology to manage waste more scientific method and metering system to account.

5 SMART METERING TECHNIQUE

Indian solid waste scenario are highly heterogeneous class produced by public or private (household waste), institutional waste and commercial waste. This category covers both the unsorted and the recyclable. The differentiates these two types of collection is just the process of garbage disposal. So, the design of a smart waste metering system that deals with both types of waste is equal until to the transfer of waste either to recycle plant for processing or biodegradable for manuring . The end priduct from the processing should go for landfill. The smart metering technique includes from begining of the waste mangement process ro end product of the cycle as under:

(1) Waste Generation

(2) Waste Collection

(3) Waste Transportation

(4) Waste Processing/Disposal

As per visionary note of Smart City smart Solid Waste Mangemnt is:

- 100% households are covered by daily door-step collection system.
- 100% collection of municipal solid waste
- 100% segregation of waste at source, i.e. bio-degradable and non-degradable waste
- 100% recycling of solid waste

Waste Generation: Price sensitive Indian market is unwilling to pay the cost of `smart` benefit. It is assuming that 100 smart cities citizen will be smart enough to pay their waste mangement process as thay will pay their utility bills. Now the question is how to meter their waste. The whole city will be censores prone or accounting their utility by individual household metering system. Need to monitoring the system is to address, account and follow. Per capita waste generation need to address first. Each household is generating waste. But no one wants to NIMBY (Not in My Back Yard). So induvidual househld should have three bucket system:

- Biodegradable : Green

- Non Bi-Degradable/Recycled : Yellow
- Hazardous : Red

Waste Collection: waste collection system has been framed in metering system with sorting of waste. Green accounting waste needs to be addressed everyday . Indian high moisture content waste would be more good manure within 12 hours system. This system will be monitored by local residential welfare. Composting plant should be mandatory to each sector. Each household will deposit or dump their waste by waste metering system. This waste will be measured by weighing machine of each floor/house and through smart card it will open the box and each individual will dump the waste. Through machinery collecting system it will be transported from individual house/ multi storyed building through convere belt and store at intermediate haul statiion and there after to compsoting plant. This waste network should be built like water pipeline/sewer line/gas line system. Each individual household should have one smart card to open the shaft and pour the bucket. Number of scratches the card will acount the value as well as measuring unit will be added with that number. Now the question is how to account the heterogenous waste and how to track only green waste. This shaft system will first scan the bucket if any hetrogenous material would find it won't open shaft. This system will be easy access to individual safe and metered for accounting each waste in terms of weight and types and cost will be levied basis of total waste. But shaft system for waste always make odour. So this system is required control engineering system like sewer. Conveor belt will be battery operated and connected with haul station. Each haul station should be mechanised to clean the belt after dispose off the waste. This mechanism can be motorised by solar system and heat generated by waste. This system will be dynamic system for accouting each waste and need to vigilance by local welfare system for awareness and maintain, repairing etc.

Yellow accounting metering system shaft will be placed beside the green shaft of residential square and can access at each floor. But the recyclable waste should be free from organic waste and hazardous`waste including battery, lead, e-waste etc. Same system shall be followed by individual and total waste would be counted by weighing system. The smart card can access to open the shaft and placed the bucket first to scan and then dump it into shaft. This shaft will be stored at underground storage system and from there trucks/ dumper can take away to destination processing plant of city.

Red waste accounting system should have access of individual/houseld by smart card and shall follow the same format once in a week to store the waste in particular underground storage system. Hazardous waste is need to take care and regular storage in residential or institutional area would be disasterous. One in a week to access for transportation system will help to monitor the waste types, quntum and management practices.

Waste Transportation:

Indian Transportation of waste is carried out by the municipalities employing vehicles like open trucks, tractor-trailers, tipper trucks and dumper placers. Transfer stations (except in a few cases as in Madras, Mumbai, Delhi, Ahmedabad and Calcutta) are not used, and the same vehicle, which collects refuse from individual dustbins, takes it to the processing or disposal site (Colon and Fawcett, 2006; Khan, 1994). The municipal solid waste (MSW) collected from the dustbins and collection points is transported to the processing or disposal sites using a variety of vehicles. In smaller (rural) towns, bullock carts, tractor-trailers, tricycles etc., are mainly used for the transportation of MSW. Light motor vehicles and lorries are generally used in big towns or cities for transport of MSW. The trucks used for transportation of MSW are generally of an open body type and are usually kept uncovered; thus during transportation, the waste tends to spill on to the road resulting in unhygienic conditions. In some cities, modern hydraulic vehicles are gradually being introduced. Collection and transportation activities constitute approximately 80–95% of the total budget of MSWM; hence, it forms a key component in determining the economics of the entire MSWM system. Municipal agencies use their own vehicles for MSW transportation though in some cities they are hired from private contractors (Ghose et al., 2006; Siddiqui et al., 2006; Nema, 2004; Bhide and Shekdar,1998).

Smart Metering system for Smart city has envisaged secure transport system from individual hoesehold to destination point. Mid term haul and spillage of waste is very common in Indian waste transportation system. Unhygenic transportation system has engulf the workers for directly hazardous waste. This smart metering system will help to eradicate the unhygenic access of waste to individual.

ISBN: 978-3-9503110-8-2 (CD-ROM); ISBN: 978-3-9503110-9-9 (Print)
Editors: M. SCHRENK, V. V. POPOVICH, P. ZEILE, P. ELISEI, C. BEYER

Green waste wil be transported through conveor belt to direct composting plant. Only mechnical way will be applicable to access the waste. Machines sytem will endores the safe mangement for smart city fot smart transport. Yellow waste would be access to transport system by transport agency. Night time acess for collecting the waste from residential and instiutional city hubs. And will be transported to processing plant. Red waste will be transported through mechnised lifting system from once in week in different part of city's redential, commercial and institutional area at night time and directly will be stored at processing plant. Agency should have log metering system for collecting waste and weighing system at processing plant. This metering system not only make sure the safe transportation but also ensuring the clean, hygenic and cost effective sytem. No of trips won't account the system, total waste quntum will be measured for accounting metering log book for tranporter.

Processing or Disposal:

The three R's are commonly used terms in waste management; they stand for "reduce, reuse, and recycle". As waste generation rates have risen, processing costs increased, and available landfill space decreased, the three R`s have become a central tenet in sustainable waste management efforts (El-Haggar, 2007; Seadon, 2006; Suttibak & Nitivattananon, 2008; Tudor et al., 2011). (Gary Davidson, 2011 et). The recycling sector in India has been in operation since the 1960's and while only a fraction of the total plastic waste is being recycled in most western countries (APME, 1995), around 75% of the plastic wastes are recycled in India (Haque, 1998). Rag pickers mainly carry out the recycling process in India and they play a vital role in the economy of solid waste recycling process (Aggarwal, et al 2005). They feed the need of the intermediary buyers, who, in turn, meet the demand of factories using recyclable solid waste as raw materials. However, the rag pickers do not have sufficient protection and are exposed to waste and sometimes even the hazardous waste present in MSW. A study carried out in 2003 has shown that 75 percent rag pickers have upper and lower respiratory symptoms (Bhattacharya, 2005). Another aspect to be noted is that plastic carry bags do not figure in the list of priorities for rag pickers, because collecting them is not profitable. This is primarily because the rewards do not match the efforts required for collection, and this leads to plastic bags continuing to pose a major threat to the environment (Narayan, 2001).

The concept of waste reduction, or waste minimization, involves redesigning products or changing societal patterns of consumption, use, and waste generation to prevent the creation of waste and minimize the toxicity of waste that is produced (USEPA, 1995). Common examples of waste reduction include using a reusable coffee mug instead of a disposable one, reducing product packaging, and buying durable products which can be repaired rather than replaced. Reduction can also be achieved in many cases through reducing consumption of products, goods, and services. The most effective way to reduce waste is by not creating it in the first place, and so reduction is placed at the top of waste hierarchies (USEPA, 2010). In many instances, reduction can be achieved through the reuse of products.

Waste management systems must remain flexible in light of changing economic, environmental and social conditions (McDougall et al., 2001; Scharfe, 2010). In most cases, waste management is carried out by a number of processes, many of which are closely interrelated; therefore it is logical to design holistic waste management systems, rather than alternative and competing options. Integrated waste management (IWM) has emerged as a holistic approach to managing waste by combining and applying a range of suitable techniques, technologies and management programs to achieve specific objectives and goals (McDougall et al., 2001).

Here Waste metering technique is such technique to approach the selection method for waste into:

Re-use

Reduce

Recycle

Reuse product can be sorted through mechanised system in processing plant ant would make again the same product and can sale the open market. This total input waste will become raw material of product. The debris of waste will be disposed off to sanitary landfill system of city. This transportation cost will be managed by processing plant itself.

Reduce: The mechanised method of reductin of size and shape of waste will make different product and metering system of transporter will get payment by the processing plant not by city municipality. City

municipality will pay the operation and maintenance cost to transport agency to follow th smart metering technique.

Recycle method is complete processing unit where hardous and recylable waste have been transported and mechanically sorted and product will generate or incinerated. The cost of this processing unit will be subsidised by municipality and individual owner in 70:30 percentage ratio.

Disposal

Uncontrolled landfilling has been mainly adopted for ultimate disposal of municipal solid waste in India; thereby causing numerous health, environmental and aesthetic hazards (Ambulkar, 2004). However, now landfilling is the most preferred method of disposal of solid wastes as it is an effective and low cost method of disposal (Ramachandran, et al). Onionskin method of lying i.e., alternate building rubbish of thickness 30 cm and municipal waste with thickness of 1 to 3 m is adopted in few cities like Delhi, Chennai and Hyderabad (CPCB, 1998). However, the numbers of sanitary landfills are extremely low compared to the dumpsites, where uncontrolled dumping is observed, leveling and provision of earth cover is rarely provided. The rag pickers are further observed to be active at disposal site. Methane gas that is emitted at the landfills is not collected, hence adding to the GHG emissions (Kumar, S., et al 2004). Despite the best efforts to reduce, reuse and recycle, there will always be residual waste requiring disposal. For that methane capturing and waste to energy plant is mandatory for smart city. Smart metering system will also accounting the heating potentiality for energy sale for waste amangement to municipality. Eah municipality will be liable to purchase energy to ensure the market of waste to energy plant establishment on cities as well as it will help to transmit energy for composting plant and individual sector energy flow for moving the bio degradable waste transporting system conveor belt.

6 CONCLUSION

The Solid Waste Manual published in 2000 by the Ministry of Urban Development (MUD) (CPHEEO, 2000) states that, “In India, the system of primary collection of waste is practically non existent thus streets are generally treated as receptacles of waste. Most cities lack primary collection systems: MSW is often left on streets or in community bins that are overflowing. House-to-house collection of MSW is carried out in only some locations in large cities in India. A large portion of the waste is collected by street sweeping, which is not done on a daily basis in some areas. The collection efficiency in India ranges from 50-90%. A survey of Indian cities in 1989 showed that the average collection efficiency was 72.5%. However, given the results of the survey, described below, the national average must have been considerably lower than 72.5%. (Gupta, Mohan, Prasad, Kansal. 1998). A study conducted by the National Institute of Urban Affairs of India in 1989 found that collection efficiencies in Indian cities were low due to two main factors: availability of labor and transportation facilities. (Gupta & Kansal,1998). Using a benchmark of 2,800 workers/million population for an optimum manpower requirement, the survey found that less than 10% of the cities surveyed met this requirement, and that over 77% of the cities had a shortfall of at least 46%. With regard to transportation, another survey used a benchmark of 320 m3/million population for transport volume. This survey concluded that 95% of the cities had a shortfall ranging from roughly 22-53%, and that 5% of the cities had a shortfall of over 68%. A more recent study in 2006 found that 70% of urban areas in India lack proper transportation facilities to transfer MSW to disposal sites.

The rapid and unplanned urbanization process lead too many problems in which solid waste is one of the aspects which are changing the nature. In the process of rapid urbanization solid waste management from a low priority, localized issue to a pervasive social and environmental problem with risks to public health and environment. MSW management is constrained by institutional weakness; lack of proper funding, lack of proper management and operational systems, public apathy, lack of municipal will become financially self-sufficient through municipal taxation, etc. Disposal is the only favorable method to urban local body without any further action. Day by day increasing trend practice of dump to dump yard won’t sustain the function. So there is a requirement of taking integrated policy and technology to use less land. Land is precious. Footstep to sustainable development it is an imperative requirement to understand the basic concepts concerned to the solid waste management practice and bare minimum requirement of land at each level. Smart metering system is web based technology for accounting waste in each step and addres to sort, process and waste won’t become waste for city but a resource of flow dynamic.

ISBN: 978-3-9503110-8-2 (CD-ROM); ISBN: 978-3-9503110-9-9 (Print)
Editors: M. SCHRENK, V. V. POPOVICH, P. ZEILE, P. ELISEI, C. BEYER

7 REFERENCES

[1] Agarwal, A., Singhmar, A., Kulshreshtha, M., Mittak, A. K., (2005). Municipal Solid Waste Recycling and A associated Markets in Delhi, India. Resources, Conservation and Recycling 44, Issue 1, 73-90.

[2] A report of National Solid Waste Association of India, (2003). Urban Municipal Solid Waste Management. Special Bulletin of the National Solid Waste Association of India (inaugural issue), Mumbai.

[3] A report of Municipal City Council of Toronto, (2012) City of Toronto Requirements for Garbage , Recycling and Organics collection for new Developments and Redevelopments , May 2012.

[4] Association of Plastics Manufacturers in Europe (APME), (1997). Information System on Plastic Waste Management in Western Europe: European overview, data 1997 France: APME Technical and Environmental Centre and SOFRES Counsel.

[5] Bhide, A. D. and Sundaresan, B. B. (1983). Solid Waste Management in Developing Countries. New Delhi, India: Indian National Scientific Documentation Center.

[6] Bhada Perinaz (2007) M. Tech Thesis on "Feasibility Analysis of Waste-To-Energy As a Key Component of Integrated Solid Waste Management in Mumbai, India, Master of Science in Earth Resources Engineering Department of Earth and Environmental Engineering Foundation School of Engineering and Applied Science Columbia University.

[7] Ministry of Urban Development (MOUD), Government of India. Solid Waste Management Manual. New Delhi: Ministry of Urban Development, 2000.

[8] CPCB, Status of Solid Waste Generation, Collection, Treatment and Disposal in Metropolis series (2000),

[9] Guidelines and Check list for evaluation of MSW Landfills proposals with information on existing landfills: Central Pollution Control Board, Ministry of Environment & Forest, PROBES/124/2008-2009

[10] Status of Solid Waste Generation, Collection, Treatment and disposal in Class II Towns: Central Pollution Control Board, Control of Urban Pollution Series: CUPS /50/1999-2000

[11] Assessment of the Status of Municipal Solid Waste Management in Metro Cities, State Capitals, Class I Cities and Class II Towns in India: An Insight. Sunil Kumar, J.K. Bhattacharya, A.N. Vaidya, Tapan Chakrabarti, Sukumar Devotta, A.B. Akolkar. Kolkatta : Central Pollution Control Board (CPCB), National Environmental Engineering Research Institute (NEERI), 2008.

[12] Kant, Ravi. Managing Director, Ramky Enviro Engineers Ltd. January 2011. Ministry of Urban Development, Government of India. Guidance Note: Municipal Solid Waste Management on a Regional Basis. Ministry of Urban Development, Government of India. [Online].

[13] Solid Waste Management in India: Options and Opportunities. Shuchi Gupta, Krishna Mohan, Rajkumar Prasad, Sujata Gupta, Arun Kansal. 2, s.l. : Resources, Conservation and Recycling, 1998, Vol. 24.