Process Safety and Environmental Protection 101 (2016) 160–169

Contents lists available at ScienceDirect

Process Safety and Environmental Protection

journal homepage: www.elsevier.com/locate/psep

Innovation in solid waste management through Clean Development Mechanism in India and other countries

Aditee Potdar, Anju Singh, Seema Unnnikrishnan, Neelima Naik, Mayuri Naik, Indrayani Nimkar*

National Institute of Industrial Engineering, Mumbai 400087, India

ARTICLE INFO

Article history:
Received 14 March 2015
Received in revised form 10 July 2015
Accepted 16 July 2015
Available online 26 July 2015

Keywords:
Municipal Solid Waste
Innovation
CDM
Land-filling
RDF
Composting

ABSTRACT

This paper focuses on the potential of Clean Development Mechanism (CDM) for Municipal Solid Waste (MSW) management in India. About 350 MSW projects are implemented through CDM across 56 countries. The maximum MSW management CDM projects are implemented in China (102) followed by Brazil (45) and Mexico (28). Fourteen countries registered two projects individually and twenty-three countries registered a single project individually. About 22 CDM projects for MSW management are registered in India. The annual estimated emission reduction from these 22 projects is 1,467,371 ton CO_2e/annum. Approved large-scale methodology (AM0025) and approved small-scale methodology (AMS III.F) are the most widely used methodologies. The highest numbers of projects are registered in the state of Delhi. These CDM projects use technologies *viz.* refuse-derived fuel pelletization, landfill capture, biogas generation, and composting. These technologies assist in reducing pollutants and landfill space, and generating energy and useful by-products. Policy and barriers for MSW management in India are highlighted and plans for implementation of more CDM projects are proposed. Though physical, operational, regulatory, and socio-economic challenges exist for MSW management, India should make the best use of the opportunity that CDM offers and develop projects to benefit in terms of finance, technology and sustainable development.

1. Introduction

Municipal solid waste management (MSWM) is one of the foremost environmental problems of Indian cities (Sharholy et al., 2008). Considering rapid expansion of the cities/towns with massive migration of population from rural to urban centers, as well as considerable rise in per capita generation of wastes with each passing day, production of MSW has continuously been increasing (Saha et al., 2010). About 1,27,486 TPD of municipal solid waste was generated from 34 states during 2011–2012; of this, 89,334 TPD (70%) of MSW is collected and only 15,881 TPD (12.45%) is processed or treated (CPCB, 2014). The per capita waste generation is 0.17 to 0.8 kg/capita/day, though the per capita waste generation varies with the economic condition of the person. Of the total waste generated in India, 48% consists of biodegradable waste (NSWAI, 2013). The appropriate selection of technology used for MSW management is dependent on many factors, such as technology efficiency, economic benefit as well as social and environmental acceptability (Zaman, 2013a). Existing MSW management system in India includes storage, collection, transportation, segregation, processing and disposal of MSW,

* Corresponding author at: Centre for Environmental Studies (CES), National Institute of Industrial Engineering (NITIE), Vihar Lake Road, P.O. NITIE, Mumbai-400087, India. Tel.: +91 022 28573371.
E-mail address: mayuri.mrn02@gmail.com (M. Naik).
http://dx.doi.org/10.1016/j.psep.2015.07.009

most of which is poorly developed (Sharholy et al., 2008; Kumar et al., 2009). Treatment and disposal methods in use in India for MSW mainly include landfilling, composting (aerobic and vermicomposting) and very few waste to energy initiatives (incineration, refuse-derived fuel and biomethanation) (Sharholy et al., 2008). India has lagged behind in terms of adopting technologies for solid waste management. In particular, collection, treatment and disposal of waste require urgent consideration (Unnikrishnan and Singh, 2010).

With tremendous increase in MSW generation and low budget allocation for MSW management authorities in India, 70–90% of MSW generated is disposed of in unsecured landfill sites (Jha et al., 2008) or uncontrolled dumping takes place on the outskirts of towns and cities, which have serious environmental implications in global warming (through release of greenhouse gas (GHG) emission) (Narayana, 2009; Singh et al., 2011). According to the fourth assessment report of the Intergovernmental Panel on Climate Change, waste and its management is one among seven key contributors to climate change (King and Gutberlet, 2013).

GHG emissions can be reduced through recovery and recycling of resources from MSW (King and Gutberlet, 2013). The principal climate-relevant GHGs generated through solid waste management activities are methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) (Gentil et al., 2009; Machado et al., 2009). The principal source for producing CH_4 is the organic portion of MSW, which is typically about 70% in Indian solid waste (Yedla and Parikh, 2002). When MSW is transported to landfills and dumped openly, immense quantities of CO_2 and CH_4 are liberated into the atmosphere (Lino and Ismail, 2011).

The net GHG emission from India was 1727.71 MT of CO_2eq in 2007, of which, 3% contribution was from the waste sector alone and 22% of this was from MSW only (INCCA, 2010). Waste avoidance and reduction technology are considered to be the prime challenge rather than the development of new waste treatment technology (Zaman, 2013b). MSW has great energy potential and its reuse, specifically the production of biogas from landfills and the recycling of solid waste, presents a favorable mechanism to optimize energy use and preserve it (Lino and Ismail, 2011). This potential of MSW can be harnessed through Clean Development Mechanism (CDM), which helps in achieving the twin objective of reducing GHG emissions and sustainable development. CDM can play a major role in managing MSW by motivating municipalities to go in for energy recovery projects as it will fetch carbon credits and make the projects financially more attractive (Unnikrishnan and Singh, 2010). Due to initiatives such as CDM, reducing greenhouse gas emissions for a developing country can offer an important route to attracting investment in a variety of qualifying project areas, including waste management (Barton et al., 2008).

2. Technologies for municipal solid waste management

MSW generation is rapidly increasing in Indian urban areas (Dasgupta and Mondal, 2012). These wastes need to be treated adequately to prevent environmental problems and enable a sustained development of modern society (Koukouzas et al., 2008). Presently, landfilling and composting are the only technologies predominantly used for waste management in India (Ambulkar and Shekdar, 2004). Vermicomposting of MSW was also suggested in some countries (Sim and Wu, 2010; Lim et al., 2015). With an alarming decrease in the availability of energy resources, there is a renewed interest in innovative ways to convert the existing reserves with more efficient technologies that may lead to a lower impact on the environment (Koukouzas et al., 2008). MSW is actually a resource with enormous potential in terms of material and energy recovery. Thus, waste-to-energy (WtE) operations have the advantages of resource generation and the minimization of land filled waste (Arafat et al., 2013). The commonly available technologies for treatment of MSW are presented.

Incineration: Thermal treatment using incineration technology has been recognized as an alternate attractive method for MSW disposal due to the primary advantages of hygienic control, relative harmlessness, volume reduction (about 90%), mass reduction (about 70%) and energy recovery (Chang et al., 1998; Malkow, 2004; Bie et al., 2007; Shi et al., 2008). As a result, incineration of MSW has received a great deal of attention in countries with little landfill space (Yang et al., 2012). MSW incineration technology with direct gasification and melting has been taken as a comprehensive technology offering high temperature, long time for gas transiting, vitrification of various residues, no lixiviation of heavy metal and lower quantity of dioxin. Organic composition gasifying and mineral melting are combined to obtain fuel gas, metal and slag using this technology (Wei et al., 2009).

Incineration does have its problems and is consequently criticized due to incomplete combustion of materials giving rise to harmful emissions, presence of chlorine leading to highly toxic dioxin and furan emissions, high operating costs and use of supplementary fuels to achieve high combustion temperatures (McKay, 2002). Products derived from MSW thermo-chemical conversion, such as syngas and bio-oil, may be directly used as fuel, added to petroleum refinery stocks, upgraded using catalysts to premium grade fuel or used as chemical feedstock. Specially, production of a liquid fuel product increases the ease of handling, storage and transport and hence, the product does not have to be used at or near the recycling plant (Wang et al., 2015).

Landfilling: Landfilling has long been the most common disposal method for MSW, especially in developing countries, because of its simplicity, low investment and operational costs and easy operation (Xiaoli et al., 2007; Aziz et al., 2010; Zhang et al., 2011; Yang et al., 2013; Yang, 2014). A typical landfill may be a source of three phases of waste products: solid (wastes), liquid (leachate) and gaseous (landfill gas), which may pose a threat to the individual elements of the environment (Melnyk et al., 2014). MSW landfills are also potential sources of offensive odors causing annoyance, which may cause decreased quality of life and negative consequences on human health and welfare (Saral et al., 2009). The impacts of generating and treating landfill gas (LFG) and leachate have been the primary concerns of researchers as the major environmental issues associated with MSW landfilling (Yang, 2014). Treatment of MSW by landfilling has been, and still is, connected with a risk of pollution (Øygard et al., 2004). If implemented properly, adoption of sanitary landfill can help in generating resources like landfill biogas, selling of digested refuse as manure as well as selling benefits of resource generation through CDM (Kumar and Sharma, 2014).

Pyrolysis: Pyrolysis is considered as an innovative alternative for treating MSW. Pyrolysis has been examined as an alternative for MSW disposal that allows energy and resource recovery (Chen et al., 2015). Pyrolysis is the thermal degradation of waste in the absence of oxygen, which results