# Solid waste management-sustainability towards a better future, role of CSR – a review

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**Abstract**

**Purpose** – *Human activities in household and industries generate an enormous amount of waste material, both organic and non-biodegradable matter, which substantially contribute to land, water and air contamination. The study aims to highlight the possible methods in solid waste management (SWM) and its influence on economy and environment. The paper is an attempt to bring out the necessity of corporate social responsibility (CSR) in the management of solid waste.*

**Design/methodology/approach** – *The paper is prepared after an elaborate review of literature connected with SWM.*

**Findings** – *The paper emphasizes the need of SWM and the role of corporate bodies in building a robust system in the management of solid waste, creating a healthy environment to all.*

**Research limitations/implications** – *The paper is entirely based on literature review and reports and not on individual's research.*

**Practical implications** – *The paper has a multi-level faceted approach where real-time practices in different countries have been explored.*

**Social implications** – *This study can enable the collaboration of corporates, scientific community and the municipal local bodies in the area of SWM.*

**Originality/value** – *This paper deliberates on how CSR can be a driving force for a sustainable model for SWM.*

**Keywords** *CSR, Transesterification, Biomethylation, Digital, Domination, Public private partnership (PPP), Solid waste management (SWM)*

**Paper type** *Literature review*

## Solid waste management – the need of the hour

Human activities like households, businesses and industries bring in a large amount of waste products in the form of solid waste, wastewater and organic waste, accompanied by emissions to air. The industrial revolution in the nineteenth century, increase in the human population from million to billions, increasing demand in goods, shortening of distances around the world, international connectivity, globalization of economy and advances in technology have changed the nature of waste generated from organic to plastics and e-wastes. Statistical data reveal that the worlds' cities generate 1.3 billion tons of solid waste per year, generating about 1.2 kg carbon footprint per person per day (World Bank, 2012). With urbanization, the waste generation is expected to rise to 2.2 billion tons by 2025 (Circle Economy, 2018a), posing a huge challenge to any country. Digital domination precipitated as a surge in gadgets, and shorter product life cycles has tremendously changed the characteristics of the waste. An estimate by the Ministry of Environment, Forest and Climate Change, Government of India affirms that about 62 million tons of waste is generated annually in the country, out of which 5.6 million is plastic waste and 0.17 million is

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biomedical waste. The per capita waste generation in Indian cities range from 0.20 to 0.60 kg per day. Out of the total 62 million tonnes per annum (TPA), only 43 million TPA is collected, 11.9 million is treated and 31 million is dumped in landfill sites. Muncipal solid waste (MSW) generation rates are influenced by economic development, the degree of industrialization, public habits and local climate. Generally, the higher the economic development, greater the amount of solid waste produced. Income level and urbanization are highly correlated and as disposable incomes and living standards increase, consumption of goods and services correspondingly increases, as does the amount of waste generated. Urban residents produce about twice as much waste as their rural counterparts.

Solid waste generation by different countries are influenced by the rate of industrialization, economic growth, local food habits and climatic conditions. The disposal of these solid wastes is critical to any population, as landfills and mismanaged waste disposition provide breeding ground for harmful vectors and rodents giving rise to potential health hazards. Waste disposal by burning and incineration contributes to greenhouse gases emission, adversely affecting the environment. Studies reveal that despite awareness in solid waste management (SWM), the planning, implementation and execution of SWM in different countries is proportional to its economic development as represented in Table I.

Figure 1 illustrates global waste generation per region: Africa (AFR), East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin America and the Caribbean (LAC), Middle East and North Africa (MENA), OECD (Organization for Economic Co-operation and Development) and South Asia region (SAR).

OECD countries make up almost half. Table II represents the projected waste generation by various regions by 2025, and Figure 2 represents the global waste generation by 2025.

The solid waste is broadly classified into organic and inorganic. The waste composition is categorized as organic, paper, plastic, glass, metals, and "other". Table III represents the sources of the byproduct generated under each category.

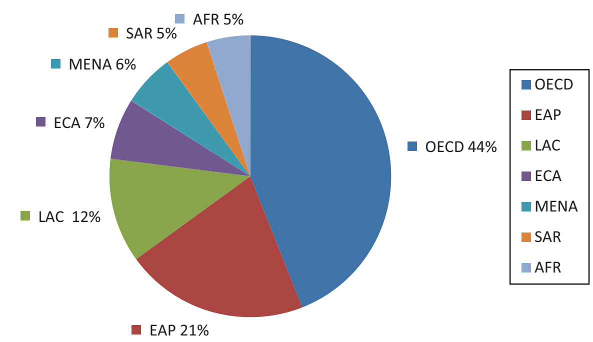
Figure 3 represents the percentage of different category of waste generated globally. Organic waste contributes to majority of the solid waste generated compared to non-organic waste.

**Table I** Comparison of SWM by different category of countries

| *Activity* | *Low income* | *Middle income* | *High income* |
|---|---|---|---|
| Costs | Collection costs represent 80%-90% of the municipal SWM budget. Waste fees are regulated by some local governments, but the fee collection system is inefficient. Only a small proportion of budget is allocated toward disposal | Collection costs represent 50%-80% of the municipal SWM budget. Waste fees are regulated by some local and national governments. Expenditures on more mechanized collection fleets and disposal are higher than in low-income countries | Collection costs can represent less than 10% of the budget. Large budget allocations to intermediate waste treatment facilities. Up front community participation reduces costs and increases options available to waste planners (e.g., recycling and composting) |
| Incineration | Not common, and generally not successful because of high capital, technical, and operation costs, high moisture content in the waste, and high percentage of inerts | Some incinerators are used, but experiencing financial and operational difficulties. Air pollution control equipment is not advanced and often by-passed. Little or no stack emissions monitoring. Governments include incineration as a possible waste disposal option but costs prohibitive. Facilities often driven by subsidies from OECD countries on behalf of equipment suppliers | Prevalent in areas with high land costs and low availability of land (e.g., islands). Most incinerators have some form of environmental controls and some type of energy recovery system. Governments regulate and monitor emissions. About three (or more) times the cost of landfilling per ton |

**Source:** WB What a Waste (2012)

**Figure 1** Global statistics on waste generation



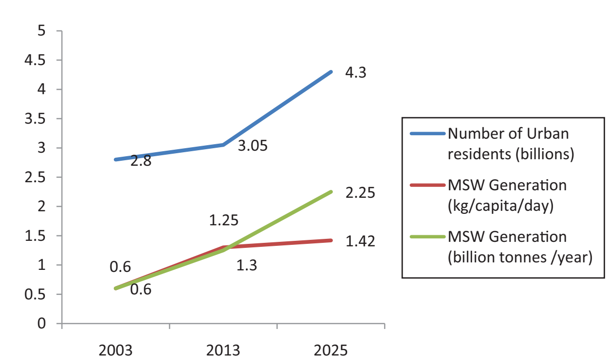

**Source:** WB what a waste (2012)

**Table II** Waste generated by various regions by 2025

| *Region* | *Current available data: Total Urban population (million)* | *Urban Waste Generation: Per capita (kg/capita/day)* | *Urban Waste Generation: Total (tons/day)* | *Projections for 2025 – Projected population: Total population (million)* | *Projected population: Urban population (million)* | *Projected Urban Waste: Per capita (kg/capita/day)* | *Projected Urban Waste: Total (tons/day)* |
|---|---|---|---|---|---|---|---|
| Africa (AFR) | 260 | 0.65 | 169,119 | 1,152 | 518 | 0.85 | 441,840 |
| East Asia & Pacific (EAP) | 777 | 0.95 | 738,958 | 2,124 | 1229 | 1.50 | 1,865,379 |
| Europe & Central Asia (ECA) | 227 | 1.10 | 254,389 | 339 | 239 | 1.50 | 354,810 |
| Latin America & the Caribbean (LAC) | 399 | 1.10 | 437,545 | 681 | 466 | 1.60 | 728,392 |
| Middle East and North Africa (MENA) | 162 | 1.10 | 173,545 | 379 | 257 | 1.43 | 369,320 |
| OECD | 729 | 2.20 | 1,566,286 | 1,031 | 842 | 2.10 | 1,742,417 |
| South Asia region (SAR) | 426 | 0.45 | 192,410 | 1,938 | 734 | 0.77 | 567,545 |
| Total | 2,980 | 1.20 | 3,532,252 | 7,644 | 4285 | 1.40 | 6,069,703 |

Source: WB What a Waste (2012)

**Figure 2** Global waste generation by 2025

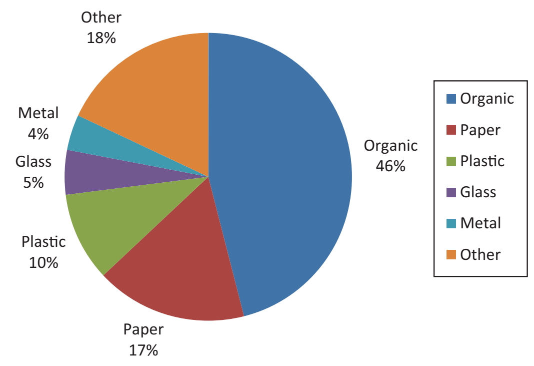



**Source:** WB what a waste (2012)

**Table III** Category of waste generation

| *Types* | *Sources* |
|---|---|
| Organic | Food scraps, garden waste, wood |
| Paper | Paper scraps, cardboard, newspapers, magazines, bags, boxes, wrapping paper, shredded paper and paper beverage cups |
| Plastic | Bottles, packaging, containers, bags, lids, cups |
| Glass | Bottles, broken glassware, bulbs |
| Metal | Cans, foil, tins, appliances, vehicle spares |
| Other | Textiles, leather, rubber, laminates, e-waste, appliances, other materials |

**Figure 3** Percentage quantity of global waste generation for different categories




**Source:** WB what a waste (2012)

## Disposal of solid waste

Scientific disposal of solid waste through collection, segregation, treatment and disposal in an environmentally sound manner minimizes the adverse impact on the environment:

$$\text{ZERO WASTE} = \text{transforming waste into valuable resources}$$

### *Segregation*

There is no scientifically organized method for the segregation of solid waste. Segregation and sorting of waste at the household, as well as at the municipality level, is carried out by unorganized sector in an unsafe hazardous conditions. The effectiveness of segregation is relatively low as the unorganized sector involved in the process value only those discarded constituents from the waste which can guarantee them higher economic return in the recycling market (Kaushal *et al.*, 2012). Improper handling again leads to mixing up of segregated waste during transportation (CPCB, 2013 Report). Lack of segregation deprives proper scientific disposal of waste (Singhal and Pandey, 2001).

### *Collection*

Waste produced by households is transferred into communal bins stationed at definite places. Waste discarded irresponsibly along the street also finds its way into collection centers and to community bins through street sweepers. Commercial sectors, industrial, hospitality and medical unit wastes are also collected by authorized municipality personnel who transfer their wastes to disposal site by paying some amount (Kumar *et al.*, 2017).

### *Reuse/recycle*

The 2R ensures that the material from the collected waste is retrieved and utilized for making new products. The optimal recycling is not possible for the waste dumped at the community bins as they are mostly unsegregated. Recyclable materials such as plastics and glass are sorted by rag-pickers and absorbed into the mainstream through recycling (Pattnaik and Reddy, 2010a, 2010b).

### *Disposal*

The waste collected in various centers is transported via tractors, trailers and trucks is usually directly disposed on low lying area. Data reveal that uncontrolled open dumping is a common feature in almost all cities (Kumar *et al.*, 2017). Landfilling continues to be extensively practiced in many developing countries. In India, metropolitan cities such as Delhi, Mumbai, Kolkata and Chennai have limited availability of land for waste disposal and designated landfill sites are running beyond their capacity (Sharholy *et al.*, 2008).

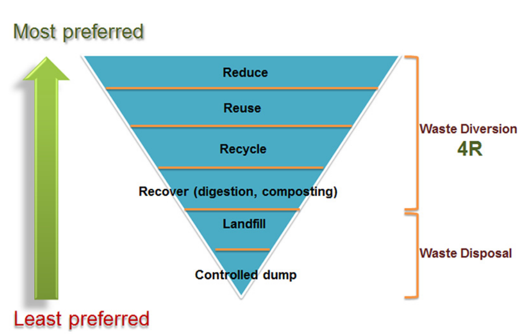
Figure 4 represent the methods of waste disposal options, and Figure 5 represents the economy associated with waste disposal and its environment implication. The SWM hierarchy can be represented as "4R" – Reduce, Reuse, Recycle and Recover. Reducing the use of single use disposable plastic items like polythene bags, disposable plastic bottles and plastic straws contributes positively to SWM, yielding largest benefits at consumer level with conducing economic and environmental implications.

## Challenges in solid waste management

### *Knowledge creation and awareness*

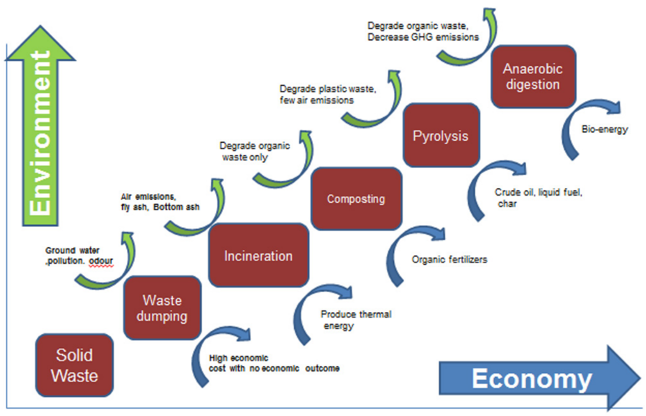
Ecological awareness and individual participation to segregate waste at source, door-to-door collection and disposal in appropriate collecting bin are imperative and remain as the primary challenge in SWM. Unscientific dumping is the major source of surface water contamination during monsoon and groundwater contamination due to percolation of leachate (Mor *et al.*, 2006). The dust and particulate matter that emanates from landfills can result in serious allergic and respiratory conditions. The toxic waste in landfills leads to soil and heavy metal contamination, forcing people out of their dwelling. $CH_4$ emission from landfill is about 13 per cent of global $CH_4$ emission and is about 818 million metric tons per

**Figure 4** Options of waste disposal




**Source:** Plastic waste solution (2012)

**Figure 5** Waste disposal – environment and economic implications




**Source:** Anjum *et al.* (2016)

annum in terms of $CO_2$ equivalent (Rachel *et al.*, 2007). In India, estimated methane emission is about 16 million metric $CO_2$ equivalents per annum through landfills (International Energy Agency, 2008). The citizen awareness on ill effects of indiscriminate dumping and landfilling plays an important role in creating an efficient waste management system.

### *Infrastructure and urbanization*

Inadequate financial support to provide adequate infrastructure build or upgrade waste sorting and treatment facilities, construct or refurbish landfills, trucks and transfer stations are yet another challenges in SWM. Urbanization and lack of capital investments to cater appropriate funding for infrastructure development act as constraints in the management of solid waste.

### *Legal policies and institutions*

A concrete policy measure, concerted effort from various governmental institutions and implementation of rules reinforced by resilient judicial structures is essential for the municipal waste management sector. Adequate training to create a dedicated group of officers and skilled staff for urban local bodies with specialization in muncipal solid waste management would enable to execute the policy on the ground.

### *Financial sustainability*

Through the design of taxes and fee structures and long-term planning, projects help governments improve waste cost containment and recovery.

### *Citizen engagement*

Behavior change and public participation is key to a functional waste management system. Public awareness systems and designing incentives can facilitate the process of SWM, enabling waste reduction, source segregation and reuse.

### *Social inclusion*

Resource recovery in most developing countries relies heavily on informal workers, who collect, sort and recycle 15-20 per cent of generated waste. The provision for creating material recovery facilities, decentralized composting, improving the working condition of waste pickers with gloves, medical claim and health checkup will aid in safe working conditions and better social participation

### *Health and safety*

Educating people on SWM improves public health and livelihoods by reducing open burning, mitigating pest and disease spread.

A comparative study on waste generation by developed and developing countries shows that 37-90 per cent of the waste generated goes into landfills, aggravating the process of soil contamination as represented in Table IV. The sustainable solution to SWM should include a balanced approach in terms of environmental effectiveness, its affordability and acceptance by the individuals.

## Corporate role in solid waste management

The challenges posed in the management of SWM are paucity of funds, lack of technical know-how, inadequate human resources and apathy of citizens to maintain cleanliness, as well as institutional weakness and lack of enforcement.

The governmental institutions are responsible for the development of infrastructure for collection, storage, segregation, transportation, processing and disposal of MSW, this gives a perfect opportunity to large and small companies to tie up with the existing informal sectors and participate.

### *Biological treatment of organic waste*

The waste generated in India has more organic content – about 50 per cent – as compared to 30 per cent generated by developed countries.

### *Aerobic composting*

Composting is defined as the phenomenon under which biological conversion of organic matter existing in MSW takes place in the presence of air under humid and warm environment. The end product of composting, having high nutrient value, is humus (compost). Composting could be either labor-intensive or mechanical. In smaller towns labor intensive composting is carried out. However, in big Indian cities, power-driven composting units have been installed (Bhide and Shekdar, 1998). An MSW composting center installed at Indore City (Madhya Pradesh) is one of the best maintained facilities. In

**Table IV** Comparison between developed and developing nations

| *Attributes* | *Developed nations* | *Developing nations* |
|---|---|---|
| World population (%) | 22 | 78 |
| Waste production (%) | 44 | 56 |
| MSW rate (kg/capita/day) (%) | 1.5-4.5 (USA, New Zealand) | 0-1.7 (China, India) |
| Waste composition (%) | 20 biodegradable ++paper, plastic, metal | 60 biodegradable |
| Waste collection rate (%) | 90-100 | >70 |
| Open dumping (%) | 33-0 | 37-90 |

**Source:** WB What a Waste (2012)

Bengaluru, Vadodara, Mumbai, Delhi and Kanpur, mechanical composting units of 150-300 tons/day capacities were also installed (Sharholy *et al.*, 2007).

### *Vermi-composting*

Vermicomposting is carried out by introducing earthworms on semi-decomposed organic waste. Earthworms can consume five times of organic matter per day as compared to their body weight. Initially, the biodegradable organic matter is decomposed through microbial enzymatic activity

### *Anaerobic digestion*

Anaerobic decomposition of waste is also known as biomethanation process. It is one of the important and sustainable techniques for treatment of the biodegradable part of MSW in subtropical climates. In this process, stabilization occurs and biogas is liberated by the conversion of organic matter, which in turn can be used as energy. The biogas has 55-60 per cent methane and can be used as fuel for power generation. Government of India encourages biomethanation technology by utilizing industrial, agricultural and municipal wastes. A number of schemes for biomethanation are under planning and inception stage for some cities such as Delhi, Bangalore and Lucknow to utilize waste generated from the vegetable market and yard wastes. (Ambulkar and Shekdar, 2004).

### *Biofuel production – an alternative to fossil fuels*

A biofuel is a fuel that is produced through contemporary biological processes, such as agriculture and anaerobic digestion, rather than a fuel produced by geological processes such as those involved in the formation of fossil fuels, such as coal and petroleum. Bioethanol is widely used as a source of energy in the USA and Brazil. Biodiesel can be used as a fuel for vehicles to reduce levels of carbon monoxide, particulates and hydrocarbons in diesel vehicles. European countries also utilize biodiesel produced to generate power from oils or fats using transesterification technology. The biofuel production upholds a greater potential in the sustainable development and substantial decrease in environmental footprint moving true north to achieve zero waste concept. The leading countries in biodiesel production are Brazil, Argentina, USA, Germany and France, with the USA topping the list, with 940,000 barrels per day (Figure 6). The capital cost involved in the management of solid waste can be provided through socially responsible business activities or corporate social responsibility (CSR) funds to develop pollution-free environment for the future generations to come. The comprehensive SWM strategy can be developed by the administration in a public private partnership (PPP) model effectively funded through CSR initiatives.

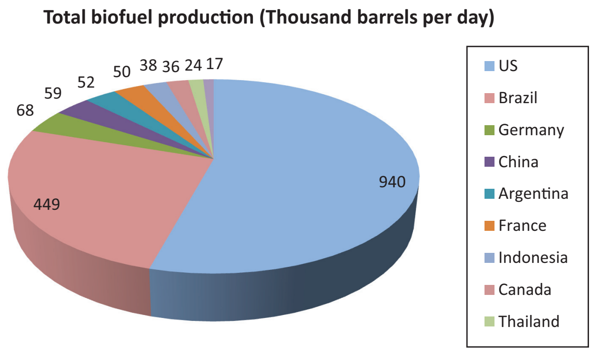
### *Public private partnership model*

While municipalities are generally responsible for solid waste services, the private sector has long been involved in the municipal solid waste sector through outsourcing arrangements and informally through waste picking and sorting.

Recent trends in the involvement of the private sector in the municipal solid waste sector in developing countries are partly driven by more stringent environmental standards and the recognition that the private sector can play a significant role in improving environmental and hygiene issues around solid waste collection and disposal. They include:

- regularizing of waste picker initiatives as part of the PPP solution;
- introduction and promotion of more output focused contracts for street cleaning and solid waste collection;

**Figure 6** Total biofuel production



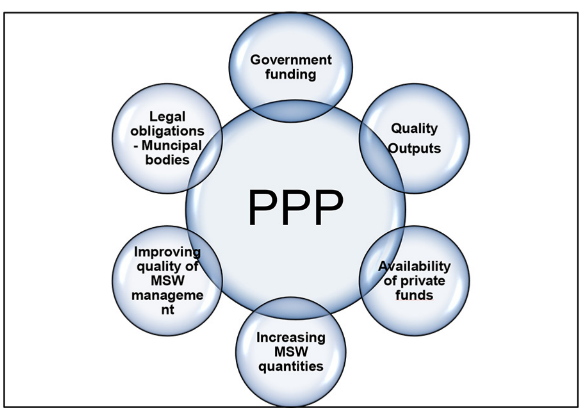

**Source:** Forbes.com

- involvement of the private sector in treatment and disposal projects to introduce technical innovation into through sanitary landfill technology, recycling and in waste to energy projects; and
- involvement of the private sector in financing capital investment Figure 7.

## Conclusion

Population growth and urbanization leading to the development of megacities and inadequate waste infrastructure are major issues associated with SWM. Public participation and regulatory rules are critical in waste management. Sustainable and economically viable waste management must ensure maximum resource extraction from waste, combined with safe disposal of residual waste through the development of engineered landfill and waste-to-energy facilities maintained by CSR initiates.

**Figure 7** Factors contributing to PPP model for SWM



## References

Ambulkar, A.A.R. and Shekdar, A.V. (2004), "Prospects of biomethanation technology in the Indian context: a pragmatic approach", *Resources Conservation and Recycling*, Vol. 40 No. 2, pp. 111-128.

Anjum, M., Waqas, M., Ahmad, I. and Barakat, M. (2016), "Solid waste management in SA: a review", *Journal of Applied Agriculture and Biotechnology*, Vol. 1 No. 1, pp. 13-26.

Bhide, A.D. and Shekdar, A.V. (1998), "Solid waste management in Indian urban centers", *International Solid Waste Association Times (ISWA)*, Vol. 71, pp. 26-28.

Circle Economy (2018a), "The circular phone", s.l.: s.n.

CPCB (2013), *Management of Municipal Solid Waste*, Ministry of Environment and Forests, New Delhi.

International Energy Agency (2008), "Turning a liability into an asset: landfill methane utilization potential in India", available at: www.iea.org/publications

Kaushal*, R.K., Varghese, G.K. and Chabukdhara, M. (2012), "Municipal solid waste management in India-current state and future challenges: a review", *IJEST*, Vol. 4, pp. 1473-1488.

Kumar, S., Smith, S.R. and Fowler, G. (2017), "Challenges and opportunities associated with waste management in India", *Royal Society Open Science*, Vol. 4 No. 3, p. 160764.

Mor, S., Khaiwal Ravindra, R.P. and Dahiya, A.C. (2006), "Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site", *Environmental Monitoring and Assessment*, Vol. 118 Nos 1/3, pp. 435-456.

Pattnaik, S. and Reddy, M.V. (2010a), "Assessment of municipal solid waste management in Puducherry (Pondicherry), India", *Resources, Conservation and Recycling*, Vol. 54 No. 8, pp. 512-520, available at: https://doi. org/10.1016/j.resconrec.2009.10.008

Pattnaik, S. and Reddy, M.V. (2010b), "Nutrient status of vermicompost of urban green waste processed by three earthworm species – eisenia fetida, eudrilus eugeniae, and perionyx excavates", *Applied and Environmental Soil Science*, Vol. 2010, Article ID 967526, 13 pages.

Rachel, G., Damodaran, N., Panesar, B., Leatherwood, C. and Asnani, P.U. (2007), "Methane to markets and landfill gas energy in India", *Proceeding of the International Conference on Sustainable Solid Waste Management*, pp. 519-525

Sharholy, M., Ahmad, K., Mahmood, G. and Trivedi, R.C. (2008), "Municipal solid waste management in indian cities - A review", *Waste Management*, Vol. 28 No. 2, Epub 12 April 2007, pp. 459-467.

Singhal, S. and Pandey, S. (2001), "Solid waste management India, status and future direction", *TERI Information Monitoring on Environment Science*, Vol. 6 No. 1, pp. 1-4.

World Bank (2012), "What a waste: a global review of solid waste management", March, No. 15.

## Further reading

Available at: www.Forbes.com/niallmccarthy/2015/12/18

Available at: www.plasticwastesolutions.com/DrRossH

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