International Journal of Advances in Engineering Research http://www.ijaer.com

(IJAER) 2018, Vol. No. 15, Issue No. III, March **e-ISSN: 2231-5152, p-ISSN: 2454-1796**

REVIEW OF SOLID WASTE TREATMENT TECHNOLOGIES

***Prem Kumar Dara, **Bol Puoch Deng, **Abiyot Mamo Terfa**

** Professor, Gambella University, Ethiopia.*
***Lecturer, Gambella University, Ethiopia.*

ABSTRACT

Waste management is a complex task involving numerous waste fractions, a range of technological treatment options, and many outputs that are circulated back into society. Zero waste is a latest visionary concept for confounding waste problems of our society. Implementing zero waste concept in modern societies is challenging. However, recent developments in solid waste management technologies gives some hope in this aspect. This paper provides some insight into these technologies, parameters for effective implementation.

Keywords: Zero waste, Waste management, modern societies, parameters

INTRODUCTION

In our society, *waste* seems to be an inevitable output of the virtually all our human activities. *Municipal Solid Waste (MSW)* is undoubtedly one of the largest products derivative from an urban lifestyle. The rapid increase of population, industrialization and urbanization have led to even greater rise in waste generation. Today, the cities of the world produce approximately 1.3 billion tonnes of municipal waste per year, amount that has increased in 90% during the past 10 years, and it is expected to double by the year 2025 (Hoornweg &Bhada-Tata, 2012).

Management of solid waste reduces or eliminates adverse impacts on the environment and human health and supports economic development and improved quality of life. The treatment of MSW should be effectively safe and most importantly, it should be environmentally sound. Reduction, reuse, recycling, sorting, segregation, processing, and disposing are major steps of integrated waste management. Now a days most health and environmental issues are related to improper waste management in towns and cities. [3]. One of the most common issue regarding old methods of waste management is the emission of greenhouse and other toxic gases from treatment and disposal procedures [2, 3]. Hence, other alternative for the management of MSW are required.

Most of the towns and cities in developing countries usually focus on disposal of waste and the most common way is landfill. This cannot only cause decrease of average landfill life but also air pollution and global warming due to the release of CO_2 and CH_4 [7, 8, 9]. Latest technologies solved this issue by introducing landfill gas based micro turbines and fuel cells [59, 60]. Hence it is the need of time to implement latest, environment friendly, and less expensive MSWM technologies in order to maintain the sustainability of planet earth [10, 11, 12].

This objective of the article is to compile recently introduced technologies of waste management from storage, collection, recycling, processing, energy recovery and final disposal.

2. COLLECTION AND TRANSPORTATION

Emerging technologies have come up in the collection and transportation of municipal solid waste in integrated waste management system [13]. Latest technologies including underground collection system, Web based GIS technology, Waste bin monitoring system using sensors and Waste compactors are being discussed further.

2.1 Underground collection system

In this system waste is stored in underground and semi underground storing systems. Waste bins or containers are being replaced by underground collection points. [14]. The collection and transportation of waste is carried out using special types of trucks. The method is beneficial for the regions with extremely hot climatic conditions as the waste would be stored underground in relatively low temperature. On the other hand, this process requires less maintenance and is more aesthetically acceptable [15].

2.2 Web based GIS (Geographic information system) technology

Over the last few years the GIS technology has gained popularity in almost every field of life. Coupling the GIS technology along with waste collecting became popular over the past few years in many countries. Through these municipalities can manage the entire waste cycle from production point to disposal areas, by optimizing and automating every step of cycle [16]. The evolution of Information and Communication technology (ICTs) has allowed the creation of efficient integrated systems which also capable to meet the requirements of the waste cycle. As GIS can model the world landmarks and streets, it can play an important role in waste collection sector. GIS in combination of other software can give information regarding the most reliable routs, number of residents, number of contracts, their validation, and potential frauds [17].

2.3 Waste bin monitoring technology using Sensors

This is one of the latest trend in the field of waste collection. In this method sensors are placed in public garbage bins to detect a certain optimum level of waste. As the garbage reaches the threshold level, indication will be transferred to the controller which will further give indication to driver of collection truck for emptying the bin urgently. The indication will be send to the driver through SMS using Mobile. [18].

2.4 Compact garbage collection trucks

In many developing countries, because of narrow and congested roads small garbage collection trucks are used. Latest technologies introduced garbage compactors in collector trucks in order to increase the collection capacity of vehicle. With continuous modification currently these trucks have achieved high compression rate as they can carry 1.5 times more waste as compare to flat pile trucks [19]. The technology does not only increase collection capacity, but also increases the fuel efficiency which is more environmentally and economically feasible. Researchers are being working to introduce electric motor drive and hybrid type collection trucks to overcome problems like greenhouse gas emissions and air pollution [19].

3. SEGREGATION AND SORTING

After collection the second step involved in MSW management system is sorting or segregation of different types of wastes for further processing [20]. Among all the steps sorting is the determining step for reuse and recycling. Latest technologies for municipal waste sorting includes optical sorting, Eddy current sorting, multi compartment bins, and optical sensor based sorting technologies [22

3.1 Multi-compartment bins

Multi compartment bins are the latest for source segregation of waste. These types of waste bins have separate compartments for different types of waste. Through this organic, paper waste and recyclables can be segregated on the spot of generation, while recyclable material can be recycled or reused, as through this method contamination can be avoided [23].

3.2 Optical sorting

Under this sorting mechanism different types of plastic, composites, and other wastes are being sorted with the help of color sensitive cameras, UV sensors and infrared spectroscopy. With the help of sensors, the position of different waste components are identified. This type of sorting is most commonly used for glass waste. Latest technology included optical sorting with laser which is relatively expensive [21].

3.4 Automated Sorting

Modern sorting plants are converting to sensor based sorting systems to improve sorting efficiency. This technology had exempted the low technology or manual sorting options. This technology is beneficial because it has high recovery rate, low operation cost and high reorganization capability. This process can convert and useless garbage to highly useful product output, which can reduce carbon footprint and emissions [24].

3.5 Mechanical Biological Treatment (MBT)

The term MBT is used for the combination of biological and mechanical processes for the transportation and segregation of waste into various outputs. MBT is be considered as pretreatment process. The main aim of MBT is the energy recovery from the waste. The biological processes are designed to minimize the content of water and the mechanical process aims to separate metals and glass from the waste. The quality of the digestate and the compost which has produced by the MBT plant can be challenging for the application on soils, due to the presence of chemical contaminants, which sometimes exceed the standard values [54].

4. RECYCLING

The best management practice is the implementation of 3Rs concept reduce, reuse and recycle. Municipal solid waste is a combination of components such as paper, plastic, glass and metal, which can be recycle and reuse certain times. Further discussed are some latest recycling and reusing technologies in solid waste management.

4.1 Deinking Technology for paper recycling

In developed countries deinking technology was introduced years ago. It is still latest in some developing countries. Through this process paper ink is removed from recycled paper slurry. In Europe the annual production of de-inked pulp has be increased up to 15%. Frequent recycling of newspaper and printed white paper can challenge the quality of paper [22]. According to studies newspaper can be recycled up to 5 times [26].

4.2 Biodegradable and degradable plastic

Arise of new technology plastic which is able to degrade 90% of itself in 90 days has resolved many issues regarding plastic disposal. Biodegradable plastic can be introduce to composting or anaerobic digestion along with organic waste in order to give productive output [22]. Many starch based plastics have been reported as biodegradable [22].

Degradable plastics does not contain stabilizing chemicals to prevent degradation due to UV light and oxygen, as compare to traditional fossil based plastic [27]. Degradable plastic have additives which help in slow and self-degradation due to the sunlight and oxygen. In this process the product slowly loose its shape and then disintegrate completely. This is known as physical disintegration [22].

4.3 Cullet remanufacturing

Mostly glass bottles are reused by refilling after returning to the shops and companies. Latest technologies have been introduced for the remanufacturing of broken glass pieces called cullet. The cullet undergoes melting and remanufacturing of glass bottles or containers. Cullet is also used as substitute in building material and as raw material in insulation [22].

5. PROCESSING

The next step in integrated waste management is processing of collected waste. Processing can helpful in decreasing the waste volume, and recovering many productive outputs including compost, steam, and electricity [28]. The main function of processing is to prolong the life of landfill site. Further will be discussing some latest technologies for waste processing and energy recovery.

5.1 Autoclaving

The technology involves treating the waste with steam at 140-160 OC for 30-40 minutes [22]. This sterilize the waste and the residue is subjected to screening. Where waste is separated on the basis of weight, organic fiber is segregated from glass and girt. Metals and plastics will send for recycling. The organic fiber has many uses including land applications and as fiber in construction industry or in the making of Refused Derived Fuel (RDFs). The residue of the process is then sent for disposal to the landfill site [29].

5.2 Fluffing

Recently a processing method has been evolved in which the solid waste is separated, sterilize and the organic portion is processed to form pulp like material known as fluff. Many processing facilities have shredders which reduce the size of paper, metal, glass, and organic waste up to 2-5cm. Batteries, carpet and other type waste is separated manually. The reduced size product is then transferred to conveyer stream where metallic portion separates out. High temperature steam is then introduced for further breaking of molecular bonds which destroys pathogens. The product is further grind, dewatered, and separated from other types of waste. The remaining is fine cellulosic material emerges as sanitized, sand like, granular fluff [30].

The fluff by product can be used as soil amendment because of its organic base and high nitrogen content. If not utilized so, the fluff can enter the landfill with 30-75% reduced volume as compare to original content. This technology is currently adopted by western countries where 95% recycling rate has been achieved [30].

5.3 Melting technology

In this technology waste is melted through electricity or fuel combustion at approximately 1400 ^{0}C [22]. This technology reduces the waste volume up to certain degree and the stable stag is obtained as a byproduct. The solidified residue has many applications in construction industry and in land reclamation. The technology has many advantages over incineration. Firstly, it overcome the problem of fly ash, and secondly the melted solidified slag has stabilized metal portion, hence it can avoid water contamination by leaching as in case of incineration [22].

5.4 Incineration

It is a thermal waste treatment process in which the unprocessed waste is burn at high temperature is commonly known as Incineration. Sufficient quantity of air is needed in order to oxidize the feedstock or the fuel. For combustion, waste has exposed to 850 ºC [31], and then it is converted to H2O, CO2, and the non-combustible material which is known as incinerator bottom ash (IBA) [32]. Recently Japanese researchers are introducing pollution free incineration by recycling incinerated ash, and removal of acidic gases through control technology [33]. Conventional stroke furnace is efficient and environment friendly incinerator reactor [34].

5.5 Vermicomposting

In this process animal waste, pharmaceutical waste, food and sewage waste is processed through earthworms to give output known as vermicompost which is very rich in Nitrogen, Phosphate and Potassium. In this process specific species of earthworms have been fed on waste which give rise to new generations to feed on waste pile. The processing period ranges from 28-120 days [37]. The temperature ranges between 18-67 oC with pH between 5.9 and 8.3 where the moisture content 80%. The vermicompost is used as bio fertilizer for crops of maize, soy bean, marigold and cow pea [37].

6. ENERGY RECOVERY

The last step in SWM before disposal is energy recovery. All the waste residue after sorting, reuse, recycle and processing, is further inaugurated for energy recovery. In 2009-2010 UK generates 32millions of waste from which 48% was returned to landfills, 39% was recycled, and energy was produced from 13% of MSW [38]. Studies reviled that energy from waste could account for 17% of UK's electricity by 2020 [38]. Latest energy conversion technologies are categorized into two broad categories, including bioconversion and thermal conversion technologies. Waste to Energy (WTE) provides a renewable alternative of energy in the world, where we have limited fossil reservoirs.

6.1 Thermal Conversion

This is a process which utilize water, heat or pressure to convert organic and inorganic waste to useful chemicals and compounds. Raw materials like plastics, computer cases, tires and crop residue are subjected to thermal processing system which convert them to useful molecules of fuel gas, oil, and other beneficial products [39]. Through these methods, even heavy metals are converted to harmless oxides [40]. Thermal technologies like incineration and combustion have been used since decades for the conversion of WTE. With the advance in technology many latest thermal treatment technologies have been introduced and are discussed further.

6.1.1 Advance Thermal Treatment Technologies

Advance thermal treatment technologies have been introduced in recent years for efficient and pollution free WTE conversion. These technologies included pyrolysis, gasification and excluded incineration. Now-a-days incineration is used as a processing technology rather as energy generating technology. Because in such a mass burn system the organic content of municipal waste is converted to heat, with the emission of CO2 and H2O, which has no fuel value and emission of greenhouse gas is a real problem. Pyrolysis and gasification are not very new concepts they have been using since decade for the production charcoal, coke and producer gas. [41].

Pyrolysis

Pyrolysis is the thermal degradation of substance in the absence of oxygen. As compare to incineration, pyrolysis is a conversion of waste to liquid or gaseous fuels along with residue char, which is a mixture of non-combustible material and carbon [42]. The temperature required for the process ranges between 300-800 ^{0}C [42]. The product gas is known as syngas which is the combination of VOCs, CO, H2, and CH4. The volatilize gases and volatilize liquids are efficiently used to run a steam engine. Cooled syngas is widely used as liquid fuel [42

Gasification

Gasification involves partial oxidation of a substance, it lies between combustion and pyrolysis. The temperature required in above 750 ^{0}C. The products are almost the same as pyrolysis; syngas and low C ash. Gasification is a reliable option as it meets the present emission standards and is helpful in maintaining the sustainability of landfill [43]. The feedstock is fed into gasifiers along with limited amount of air. Many downstream gasification processes require syngas to be cleaned from trace level of impurities. The most common impurity is mercury. Carbon bed technology has been utilized for cleanup in recent years [44]. The products of gasification are steam, chemicals, electricity, hydrogen, fertilizers, and natural gas [44]. Different types of waste gasification methods are characterized on the basis of oxygen medium, two of them are steam gasification and plasma gasification.

6.2 Bio-conversion

According to Food and Agriculture Organization (FAO), One third of the total produced food for the consumption of the human was lost along the supply chain food globally [52]. For possible energy recovery, currently food waste and other combustible waste are collectively incinerated and landfilled. However, the upper two techniques are facing more environmental and economic issues. Food waste can be used to produce biofuel through different fermentation processes. Currently, valorization is being used for the production of hydrogen, ethanol, biodiesel and biogas [53].

7. DISPOSAL

The common and old methods of municipal solid waste disposal were open dumping, burning and incineration [56]. The process of open dumping leads to water and air pollution in the form of land litter, particulates and toxic gases. Methane gas and solid residues are also produced from burning process. Disposal is the last step of MSWM, where the remaining trash after recycling, processing, and WTE is disposed of [56]. Disposal is the most technical step of waste management. Experts are encouraged to introduce technologies to lessen the amounts disposed of annually. In developing countries even today most of the disposal sites are open dumps, they have no proper leachate treatment and landfill gas utilization system [61]. Methods like open dumping were responsible for causing many aesthetic and other environmental issue [57]. Two most common ways of disposing MSW are landfills and deep well injection slurry [63, 64]. Following are modern landfill technologies through which the experts can avoid issues regarding leachate leaking, water contamination, and landfill gas explosion.

7.1 Sanitary Landfill

Landfill is a professionally engineered depression in low population area, for the final disposal of left over after all the previous steps of integrated waste management [63]. Waste is buried in that depression in order to avoid any hydraulic connection between trash and environment including air and water. Landfill is mostly preferred because it has the widest range of capabilities and is least expensive method of waste disposal. 66.

7.1 Bioreactor Technology

The latest technology to process disposed of waste rapidly is bioreactor technology. The basic aims of this technology are to enhance the rate of decomposition, circulation of leachate and increase in the growth of microbes, which decompose municipal waste. The waste is then dried by Conventional landfill technology [58].

7.2 Landfill gas recovery technologies

The landfill gas emissions are greatly varied due to geological, hydrological and geotechnical properties which have environmental impacts. The biotic and abiotic factors lead to generation of gas at landfill which is the combination of CH_4 and CO_2. Which is known as biogas. If mismanaged this gas can cause explosion of landfill or gradual leaking can cause global warming as both the gases (CH4 and CO2) are greenhouse gases [59].

Micro turbine Technology

Modern landfills have micro turbines for generation of electricity from landfill gas. This technology is used to supply electricity to the small scale nearby projects. This technology is helpful in resolving the issue of air pollution and global warming due to the emission of landfill gas. [59].

Fuel cell Technology

Energy from fuel is converted into electrical energy in an electrochemical cell is called fuel cell. Fuel supply and oxidizing agent react to generate electricity. Carbon dioxide, water vapors, heat and electricity are the end products of fuel reactions. Generation of transportation fuel for cars and buses without combustion is the application of fuel cell [60].

8. CONCLUSION

The sustainable management of municipal solid waste can reduce the short and long term environmental and human health hazards. The article concluded that proper implementation of latest technologies in the sector of MSW management can play a very important role in providing pollution free and sustainable environment.

REFERENCES:

1. Tozlu A, Özahi E, Abuşoğlu A. Waste to energy technologies for municipal solid waste management in Gaziantep. Renewable and Sustainable Energy Reviews. 2016; 54:809-815.
2. Cheng Hu Y. Municipal solid waste (MSW) as a renewable source of energy: Current and future practices in China. Bioresource Technology. 2010; 101(11):3816-3824.
3. Sharholy M, Ahmad K, Vaishya R, Gupta R. Municipal solid waste characteristics and management in Allahabad, India. Waste Management 2007; 27(4):490-496.
4. Ziadat A, Mott H. Assessing solid waste recycling opportunities for closed campuses. Management of Env Quality 2005; 16(3):250-256.
5. Turan N, Çoruh S, Akdemir A, Ergun O. Municipal solid waste management strategies in Turkey. Waste Management 2009; 29(1):465-469.
6. World Bank, What a Waste: Global Review of Solid Waste Management, 2012.
7. Shekdar A. Sustainable solid waste management: An integrated approach for Asian countries. Waste Management 2009; 29(4):1438-1448.
8. Themelis N, Kim Y, Brady M. Energy recovery from New York City municipal solid wastes. Waste Management & Research 2002; 20(3):223-233.
9. Hoornweg D, Thomas L. What a waste. Washington, D.C.: World Bank, Urban Development Sector Unit, East Asia and Pacific Region, 1999, 32.
10. Norbu T, Visvanathan C, Basnayake B. Pretreatment of municipal solid waste prior to landfilling. Waste Management 2005; 25(10):997-1003.
11. Zhu DAsnani P. Improving municipal solid waste management in India. Washington, D. C: World Bank, 2007.
12. Ahmed A. Environmental Properties of Waste and By-Product Materials Used in Constructions. J solid waste technolmngmnt. 2014; 40(2):160-169.
13. Townsend T, Powell J, Jain P, Xu Q, Tolaymat T, Reinhart D. Sustainable practices for landfill design and operation.
14. Sexton D, Spelman D. Current best practices and guidelines. Cardiology Clinics. 2003; 21(2):273-282.
15. Zia H, Devadas V. Urban solid waste management in Kanpur: Opportunities and perspectives. Habitat International. 2008; 32(1):58-73.

16. Idowu A, Adagunodo E, Esimai O, Olapade T. Development of A Web based GIS Waste Disposal Management System for Nigeria. International Journal of Information Engineering and Electronic Business. 2012; 4(3):40-48.
17. Rada E, Ragazzi M, Fedrizzi P. Web-GIS oriented systems viability for municipal solid waste selective collection optimization in developed and transient economies. Waste Management. 2013; 33(4):785-792.
18. Arebey M, Hannan M, Basri H, Begum R, Abdullah H. Integrated technologies for solid waste bin monitoring system. Environmental Monitoring and Assessment. 2010; 177(1-4):399-408.
19. Sembiring E, Nitivattananon V. Sustainable solid waste management toward an inclusive society: Integration of the informal sector. Resources, Conservation and Recycling. 2010; 54(11):802-809.
20. Mickael D. Categorization and Sorting for Waste Management. Int J Waste Resour. 2016, 6(2).
21. Schott A. Modern solid waste management in practice, 2001, 47.
22. Christensen T. Solid waste technology & management Chichester, West Sussex, U.K.: Wiley, 2011, 108.
23. Metcalfe A, Riley M, Barr S, Tudor T, Robinson G, Guilbert S. Food waste bins: bridging infrastructures and practices. The Sociological Review 2012; 60:135-155.
24. Wangyao K, Towprayoon S, Chiemchaisri C, Gheewala S, Nopharatana A. Application of the IPCC Waste Model to solid waste disposal sites in tropical countries: case study of Thailand. Environmental Monitoring and Assessment 2009; 164(1-4):249-261.
25. Gutberlet J. Waste, poverty and recycling. Waste Management 2010; 30(2):171-173.
26. Wangyao K, Towprayoon S, Chiemchaisri C, Gheewala S, Nopharatana A. Application of the IPCC Waste Model to solid waste disposal sites in tropical countries: case study of Thailand. Environmental Monitoring and Assessment 2009; 164(1-4):249-261.
27. Fairbridge R. Book Review: KanarischeInseln: Lanzarote, Fuerteventura, Gran Canaria, Tenerife, Gomera, La Palma, Hierro (second edition). The Holocene 1998; 8(3):370-372.
28. Kanat G. Municipal solid-waste management in Istanbul. Waste Management 2010; 30(8-9):1737-1745.
29. Vehlow J. Municipal solid waste management in Germany. Waste Management 1996; 16(5-6):367-374.
30. Narayana T. Municipal solid waste management in India: From waste disposal to recovery of resources. Waste Management 2009; 29(3):1163-1166.
31. Zaman AU. Comparative study of municipal solid waste treatment technologies using life cycle assessment method. Int. J Environ. Sci. Tech. 2010; 7(2):225-234
32. Jones A, Harrison R. Emission of ultrafine particles from the incineration of municipal solid waste: A review. Atmospheric Environment. 2016; 140:519-528.
33. Bunce S. Seychelles Incinerator Sustainability Preliminary Study. January, 2010 .

34. Venice 2010 – Third International Symposium on Energy from Biomass and Waste. Waste Management. 2010; 30(3):548.
35. Bosmans A, Vanderreydt I, Geysen D, Helsen L. The crucial role of Waste-to-Energy technologies in enhanced landfill mining: a technology review. Journal of Cleaner Production. 2013; 55:10-23.
36. Lombardi L, Carnevale E, Corti A. A review of technologies and performances of thermal treatment systems for energy recovery from waste. Waste Management. 2015; 37:26-44.
37. Gupta R, Garg V. Potential and possibilities of vermicomposting in sustainable solid waste management: a review. International Journal of Environment and Waste Management. 2011; 7(3/4):210.
38. Brennand T. Renewable energy in the United Kingdom: policies and prospects. Energy for Sustainable Development 2004; 8(1):82-92.
39. Marculescu C. Thermal-chemical treatment of solid waste mixtures. Energy Procedia 2011; 6:558-564.
40. Price A. UK power: an everchanging challenge for civil engineers. Proceedings of the Institution of Civil Engineers - Civil Engineering 2005; 158(6):4-11.
41. Kalinauskas Z. Interdependence between the Advance in Science and the Advance in Technology. Moksloirtechnikosraida 2010; 1(2):157-166.
42. Kothari R, Tyagi V, Pathak A. Waste-to-energy: A way from renewable energy sources to sustainable development. Renewable and Sustainable Energy Reviews 2010; 14(9):3164-3170.
43. Arena U. Process and technological aspects of municipal solid waste gasification. A review. Waste Management 2012; 32(4):625-639.
44. Arena U, Zaccariello L, Mastellone M. Fluidized bed gasification of waste-derived fuels. Waste Management. 2010; 30(7):1212-1219.
45. Heberlein J, Murphy A. Thermal plasma waste treatment. Journal of Physics D: Applied Physics. 2008; 41(5):053001.
46. Hernandez-Atonal F, Ryu C, Sharifi V, Swithenbank J. Combustion of refuse-derived fuel in a fluidised bed. Chemical Engineering Science 2007; 62(1-2):627-635.
47. Sarc R, Lorber K. Production, quality and quality assurance of Refuse Derived Fuels (RDFs). Waste Management 2013; 33(9):1825-1834.
48. Bosmans A, Helsen L. Energy from waste: Review of thermochemical technologies for Refused Derived Fuel (RDF) treatment. Third International Symposium on Energy from Biomass and Waste, Venice, 2010
49. Bosmans A, Vanderreydt I, Geysen D, Helsen L. The crucial role of Waste-to-Energy technologies in enhanced landfill mining: a technology review. Journal of Cleaner Production. 2013; 55:10-23.

50. Tame C. Energy recovery from waste by use of fluidised-bed technology. International Journal of Environmental Technology and Management. 2001; 1(1/2):192.
51. Marsh R, Griffiths A, Williams K, Wilcox S. Physical and thermal properties of extruded refuse derived fuel. Fuel Processing Technology 2007; 88(7):701-706.
52. Dasgupta B, Mondal M. Bio Energy Conversion of Organic Fraction of Varanasi's Municipal Solid Waste. Energy Procedia 2012; 14:1931-1938.
53. Uçkun Kiran E, Trzcinski A, Ng W, Liu Y. Bioconversion of food waste to energy: A review. Fuel 2014; 134:389-399.
54. Amlinger F, Peyr S, Cuhls C. Greenhouse gas emissions from composting and mechanical biological treatment. Waste Management & Research 2008; 26(1):47-60.
55. Fdez.-Güelfo L, Álvarez-Gallego C, Sales Márquez D, Romero García L. Dry-thermophilic anaerobic digestion of simulated organic fraction of Municipal Solid Waste: Process modeling. Bioresource Technology. 2011; 102(2):606-611.
56. Feng Li R. The Composting Treatment of Residue from Biological Municipal Waste Anaerobic Digestion. AMR 2010; 129-131:703-707.
57. Stone R. Municipal solid wastes and their disposal. Environmental health perspectives 1978; 27:239-244.
58. Guivarch C, Hallegatte S. 2C or not 2C?. Global Environmental Change 2013; 23(1):179-192.
59. He R, Liu X, Zhang Z, Shen D. Characteristics of the bioreactor landfill system using an anaerobic–aerobic process for nitrogen removal. Bioresource Technology 2007; 98(13):2526-2532.
60. Zhang Y, Yue D, Nie Y. Greenhouse gas emissions from two-stage landfilling of municipal solid waste. Atmospheric Environment 2012; 55:139-143.
61. Al-Awadhi JAl, Shuaibi A. Potentiality of Zubair Formation for deep slurry injection in Kuwait. Environ Earth Sci 2012; 67(5):1269-1280.
62. Gewald D, Siokos K, Karellas S, Spliethoff H. Waste heat recovery from a landfill gas-fired power plant. Renewable and Sustainable Energy Reviews 2012; 16(4):1779-1789.
63. Cheremisinoff N. Handbook of solid waste management and waste minimization technologies. Amsterdam: Butterworth-Heinemann, 2003, 98.
64. Tsang C, Apps J. Underground injection science and technology. Amsterdam: Elsevier, 2005.
65. Guerrero L, Maas G, Hogland W. Solid waste management challenges for cities in developing countries. Waste Management 2013; 33(1):220-232.
66. Manaf L, Samah M, Zukki N. Municipal solid waste management in Malaysia: Practices and challenges. Waste Management 2009; 29(11):2902-2906.