Waste Disposal: Sustainable Waste Treatments

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Chapter 3
Waste Disposal:
Sustainable Waste Treatments and Facility Siting Concerns

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ABSTRACT

Through the human municipality growing and industrialization process, productions of municipal solid waste have been growing in parallel line. The properties and composition of municipal solid waste as the main solid waste produced by human has cultural, regional, social habits and behavior, beside the economic condition, influences the properties and compositions of waste disposal, which contains process that start after collecting and transporting MSW to landfill site. After site selection, the process of recycling, waste composting and incineration will be assessed as intermediate disposal methods. Our final goal in waste disposal focused on environmental protection. This chapter will have a review on recycling merits and as effective ecofriendly methods for disposing municipal solid waste (MSW) for saving greenhouse gases (GHGs). Incineration as a commercial waste disposal will also be reviewed. Making decision about waste disposal is a multi-criteria issue because of MSW mixture, climacteric of area, cultural and economic condition, technical support, and environmental impact.

INTRODUCTION

Civilization and industrialization cause to produce of municipal solid waste (Parfitt, Barthel et al. 2010, Lim, Chen et al. 2013). Global solid waste production was 1636 million tons per year(Robinson 2009), meanwhile (Soltani, Hewage et al. 2015) indicate that ten years ago global MSW production was 0.6 billion tones /year, so it equal 0.64 kg of MSW / person /day and nowadays MSW generation had been reached

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to 1.3 billion tones /year which is equal to 1.2 kg /person/day. For the year of 2025 municipal solid waste production is estimated to reach 2.2 billion tons per year (Soltani, Hewage et al. 2015). Most common waste disposal methods are incineration, composting, recycling and landfilling (Magrinho, Didelet et al. 2006, Narayana 2009).Nevertheless some literatures indicate to recycling and landfilling as final waste disposal(Demirbas 2011). As a matter of fact, municipal solid waste (MSW) has mutable composition, with the main ingredients being; (40–60%) edible waste Products; (20%) paper and cardboard; and up to 40% glass plastic and metal (Costa, García et al. 1991). Meanwhile, Zhang et al. (2015) presented their waste disposal research on long term manned spacecraft and(Tanabe & Hoshino 2015)concentrated on secondary waste generated from wastewater treatment and as well as these issues should be added to our waste disposal subject, but we will concentrate on the ground side of waste disposal . With considering specification and characteristic of MSW, process of waste disposal should be planned. A fundamental activity, which should be in the first level of importance, is the site selection. Following siting process is another critical basic; managing recycling metals (mostly iron), plastic, paper and glass will be carried out. Other disposal methods that are the same as incineration and composting, decrease the volume of MSW and increase the suitability of application in other industry such as filler in construction (incineration ash) or agricultural nutrient (compost). Based on the local, national, and global limitation, merit of this chain of managing waste system may be arranged in different respect. Managing system for waste disposal mainly depends on the composition of MSW and the rate of development has the most critical effect on mixture of solid waste as well as social and regional factors (Denafas, Ruzgas et al. 2014).

SITE SELECTION

One of the most important parts of waste disposal process is site selection, which nowadays going on to be converted as critical factors by countries such as China(Zheng, Song et al. 2014), Brazil (Kannan, de Sousa Jabbour et al. 2014) and India(Suthar & Sajwan 2014) These countries are improving their standards to tackle this issue. Also Swartzbaugh (1993) mentioned that site selection is one of the three major phases in his presented method in USA, and the strategy and planning of waste disposal starts after site selection .

Critical Factors

There are many effective elements, which normally considered for site selection. Ekmekçioğlu et al. (2010) compared four alternative locations in Turkey for selection of best site for waste disposal. They carried out the study considering elements such as hydrology, topography and soils, adjacent land use, climate, flora and fauna, site capacity, road access and cost of the land. Some of the related elements and their relationship is presented based on obtained data from researches. The following points are related researchers on above-mentioned factors in siting issues:

- Generally, sites with slopes exceeding 1:5 are not considered good, as there might be a risk of soil erosion (Tadros 2009).
- The leaching process has critical impact on the environment, depends on two factors: The landfill hydrology and, the geochemistry of landfill material (Johnson, Richner et al. 1998). Hydrological

factor is the major factor that should be considered for subsequent treatment of leachates beside the leachate quantity data (Tatsi & Zouboulis 2002).

- Site capacity is considered as the key in deciding factor in fuzzy method of Turkey (Ekmekçioğlu, Kaya et al. 2010), for selecting waste disposal site between four nominated locations.
- The efficiency of municipal solid waste (MSW), depends on two major factors, transport capacity and manpower availability(Sharholy, Ahmad et al. 2008).
- Public health and environmental protection are the fundamental consideration for site selection (Önüt and Soner 2008).
- Flora and fauna and human health are reported as most important environmental risk in recycling solid waste (Pappu, Saxena et al. 2007).

Software and Analyzing Technique Application in Site Selection

During recent decades, there has been a rapid growth of attention in the application of computer base program for managing environmental problems (Ijäs, Kuitunen et al. 2010). As previously mentioned, many factors affect site selection. Furthermore, these elements also have internal and external correlation and limitation so application of mathematical and technical software will be suitable in the selection process. Recently, a mixture of these techniques have been used in various researches to show a more clear and trustworthy picture. Önüt and Soner (2008) used AHP, TOPSIS and MCDA, Şener et al. (2011) applied GIS and AHP, Shahabi et al. (2014) used from AHP and GIS. These techniques are notused specifically only for waste disposal method or site selection but also are widely applied in many sides of knowledge body. Some of these techniques are mathematical and usually subjective considerations or may ignore qualitative. Decision maker can easily use linguistic terms to describe a value as an alternative. Some of the well-known methods (abbreviation) are presented and defined As follows (Soltani, Hewage et al. 2015); AHP (analytical hierarchy process)

- TOPSIS (technique for order preference by similarity to ideal solution)
- MCDA (multiple criteria decision analysis)
- MILP (mixed integer linear programming)
- RIAM (rapid Impact Assessment Matrix)
- WLC (weighted linear combination)
- GIS (geographic information system)

Fuzzy Multiple Criteria Analysis (FMCA)

Based on the fundamental of this method, user should find the main criterion and then assess multi criteria through proposed methodology. The weights for selection criteria can be determined by fuzzy pairwise comparison matrices of Analytic Hierarchy Process (AHP). Furthermore, relative importance of the selection criteria could be determined by a fuzzy AHP procedure. This method had been used successfully by Önüt and Soner (2008), and Ekmekçioğlu et al. (2010) in Turkey .They reported that MCA method is a suitable assessment system for both site selection and disposal method.

Geographic Information System (GIS)

In a general sense, Geographic Information System (GIS) or spatial management of risk (Brugnot 2010), is a computer base information system, which designed to relate unrelated information of which key index variable is location. GIS had been applied to the water management, land researches and environmental risk assessment. GIS is also considered powerful decision supportive tools capable of performing spatial engineering analysis in different environmental modeling applications(Lukasheh, Droste et al. 2001). GIS had been used successfully in landfill siting by using vehicle routing and scheduling in the collection of solid waste(Chang, Lu et al. 1997).Nowadays, GIS is also being used at biogas plant sites in Finland(Höhn, Lehtonen et al. 2014), landfill site at Saqqez city in Iran(Shahabi, Keihanfard et al. 2014), and air pollution mapping in urban area(Kumar, Mohan et al. 2015).

Mixed Integer Linear Programming (MILP)

This is an optimizing program that is used for subjects, in which all or some of the variables are integers only (Sawik 2011). After collecting all related information about feasibility or optimization of linearly varying single or multiple variables, it can be applied as an engineering tool for waste disposal (Balaman & Selim 2014., Vadenbo, Hellweg et al. 2014). The adaptability of this system makes it suitable for various researches such as determining optimal recycling program (Baetz and Neebe 1994), environmental impacts(Chang, Yang et al. 1996), recycling waste(Louis and Shih 2007) rivers logistic activities.

Rapid Impact Assessment Matrix (RIAM)

Many traditional methods, which are usually applied for environmental impact assessment (EIA), produce a lot of data and information (quantitative and qualitative). Judgment on the same basis and giving a clear picture for permanent judgment are the main objectives in these issues. The computerized rapid impact assessment matrix (RIAM) can show enhanced graphical and clear pictures of matrix information. Furthermore, it gives the opportunity to evaluate development options(Pastakia & Jensen 1998). The original rapid impact assessment matrix has five evaluation criteria(Pastakia & Jensen 1998) contain: A1: Impact importance, A2: Magnitude, B1: Permanence, B2: Reversibility, and B3: Cumulatively .Depending on the environmental impact assessment(EIA) the matrix can be adjusted. Some of the real studies, which were carried out with above mentioned computer base method, are presented in Table 1.

MUNICIPAL SOLID WASTE RECYCLING

According to the report of Ang (2008), which was carried out about economic development, in the long run, of energy consumption and pollutant emission in Malaysia. Pollution and energy usage have positive relation. Malaysia as a leading country in tropical tourism have more than 261 active landfills (Kamaruddin, Yusoff et al. 2014)and previous report showed that the number of landfills was 230(Alkassasbeh, Heng et al. 2009). In five years there was 11.87 percent of growth, which gives a clear picture about the future scenario of waste disposal. Increasing maintenance cost on one hand and lack of land on the other hand are the factors for finding another alternative method for waste disposal(Zia, Bhatti et al. 2007). Waste disposal together with in homogenous nature of municipal solid waste puts more pres-

Table 1. Some real experiences with applied method for siting projects

Year/Authors	Country	Methods	Objective	Result
(Batarseh, Reinhart, & Berge, 2010)	India	RIAM	Select new site for waste disposal	Suitable methods for establishing the waste disposal facility in any urban center
(Ghose, Dikshit, & Sharma, 2006)	India	GIS	planning an effective solid waste management system	Proposed model have high efficiency in any kind of waste management
(Ijäs et al., 2010)	Finland	RIAM	1-possibilities of enlarging the scoring system 2-adjustability in different situations	This method is a conservative in character for judgment.
(Visvanathan, Visvanthan, Yin, & Karthikeyan, 2010)	Finland	GIS	1-spatial distribution 2-amount of potential biomass for biogas	GIS gives the most suitable location identification
(Ekmekçioğlu et al., 2010)	Turkey	Fuzzy multi criteria	disposal method and site selection	Suitable method for siting and disposal method
(Onüt & Soner, 2008)	Turkey	Fuzzy multi criteria	Solid waste transshipment site selection	Mathematical models can be combined with the existing method
(Shahabi et al., 2013)	Malaysia	GIS,AHP,WLC and Boolean logic	Waste disposal site locating in Saqqez	AHP and WLChad better decision making powers for locating landfill site
(De Feo & De Gisi, 2014)	Italy	MCDA,GIS	Minimizes the wasting of space for the siting	Better results in Combination model

sure on effective disposal methods, when considering socio-economic criteria is a multi-environmental project(Soltani, Hewage et al. 2015).Installation of incineration facilities is surrounded by serious challenge. Meanwhile, recycling opportunities and organic material treatment are available as replacements. Furthermore, recycling contain GHGs saving merit(Mohareb, Warith et al. 2008).

Literature Review

Waste disposal is considered as a social and political issue all around the globe . Recycling is a major section of waste disposal and could be considered as a valid response to a critically catastrophic environmental crisis (Beal 2012). More than 90% of municipal solid waste (MSW) in Indian cities, disposed of, unscientifically in open damp and landfilling method (Sharholy, Ahmad et al. 2008).In order to earn sustainable conversion of MSW to useful products, improving recycling process is the key (Read 1999). Also for most municipalities, recycling had been proved costly in compare with landfilling(Lave, Hendrickson et al. 1999). Meanwhile, in economic assessment of literature, cost of landfill disposal is lower than recycling. However, after considering the externalities, recycling could be presented as economically efficient(Lavee 2007). Affluent countries (mostly developed countries) provide substantial financial and supervisory capitals for recycling waste fractions, such as metals, glass, plastics, and paper. In contrast, for developing economies, recycling is an economic activity in certain sectors of the society(Sanneh, Hu et al. 2011).Survey results for population estimation of the cyclists in various slums shows that, in 90,000 population area 1500 cyclists are there(Agarwal, Singhmar et al. 2005) and their income is sufficient for food and accommodation for a day. In developed countries or some parts of developing countries, social charity groups are working on recycling in living complex(Council & Hawkins 2014). To sum it up, social aspect of waste disposal is highly correlated to economic condition and developing rate of civilization area. On the other hand, land availability for waste disposal plays a critical role in waste disposal policy. Currently, zero waste strategy is reviewed by(Cole, Osmani et al. 2014). England (Read 1999) and Japan (Sakai 1996, Lim, Chen et al. 2013) are suitable samples for recycling care, methods and strategies . There are different reports on recyclable percentage of municipal solid waste such as 25%(Metin, Eröztürk et al. 2003), 50%(Holloway 1989) and based on a questioner study carried out by (Lavee 2007) shows that recycling ranges from 10% to 80%. In the light of this, prediction of the recyclable component should be made by studying the percentage composition of each material in MSW, such as plastic, paper, metals and glasses (Saeed, Hassan et al. 2009). Normally, Volume % of recyclable material in MSW is many times higher than weight %. This could be a fundamental reason of importance for recycling in waste disposal especially on the medium and large sized municipalities(Lavee 2007). Electricity consumption in material recovery facility ranges from 4.7 to 7.8 kWh for each metric ton of solid waste impute (Pressley, Levis et al. 2015). Consequently, in any site with comparing global price of raw materials and recovery cost, efficiency of recycling can be calculated. International standard organization (ISO) published two specific environmental standard (Standardization 1997, Standardization 2006) for life cycle assessment, which are widely applied for MSW management process(Diaz & Warith 2006). Environmental justifications of recycling are mentioned by Daskalopoulos et al. (1997) are as follows:

- Move towards sustainable economies by conservation of non-renewable resources
- Energy consumption due to production process will decrease
- Significant decrease in cost of waste management
- Increasing the landfill life
- Pollutant emissions due to production and waste disposal will decrease
- Benefits of participation in environmental education

Recyclable materials are divided into sub materials, which depend on industrialization rate and packaging in food industry. Sub materials for plastic, paper, glass and Aluminum presented by Agarwal et al. (2005). According to Palmer et al. (1997) the least expensive of the policies for waste disposal (aluminum, paper plastic and steel) is deposit/refund.

Recyclable Plastic Materials

Plastics are widely used in humankind's life. Furthermore, plastic production in society is higher than steel, and is increasing year by year(Yoshioka & Grause 2015). Percentage of plastic solid waste in MSW is also increasing (Al-Salem, Lettieri et al. 2009). Recycling is the best method for treatment of plastic materials considering stable chemical and physical characteristic(Li, Wu et al. 2015) . Specially assessment case study in Spain shows that high-density polyethylene (HDPE), low density polyethylene (LDPE), polyethylene terephthalate (PET), polyvinylchloride (PVC), expanded polystyrene (EPS), polystyrene (PS), liquid packaging board (LPB), and material recover facility(MRF) are detected in MSW (Bovea, Ibáñez-Forés et al. 2010). Major plastic sources are PVC and PET(Yoshioka & Grause 2015).

According to Holloway (1989), steam separation method in municipal solid waste recycling have higher efficiency in recycling of plastic materials. Quality of recycled plastic vary widely in terms of color, mixed materials and density meanwhile, through the different types of plastic materials, PET recycling framework can also be considered as an acceptable method for preparation of raw material. High quality recycled PET cab be used as a raw material in different industries (Yoshioka & Grause 2015). According to Scheirs and Kaminsky (2006)and Al-Salem et al. (2009), higher quality and process of separation in recycling plastic such as tertiary and quaternary treatment scheme following primary and secondary treatment technologies and schedules, could be considered as a robust, worse scientific and traditional investigation. Preliminary researches such as (Yoshioka, Sato et al. 1994, Paszun and Spychaj 1997) tried chemical treatment for recycling. Manufacturing high quality carbon for phenol adsorption was carried out by Parra, Ania et al. (2004). Recent researches are focused on hydrocyclonis separation (Yuan, Fu et al. 2015), froth flotation as recycling technology (Wang, Wang et al. 2015), and using waste PETs as filler in phenolic resin mold (İyim & Orbay 2015) . Worldwide plastic production and power application for producing in plastic manufactories consumes 8 percent of total oil production. In Europe and USA, plastic recycling has reached to 26% and 9% respectively, which clearly shows that recycling industry have great scope for improvement (http://www.worldwatch.org 2012).

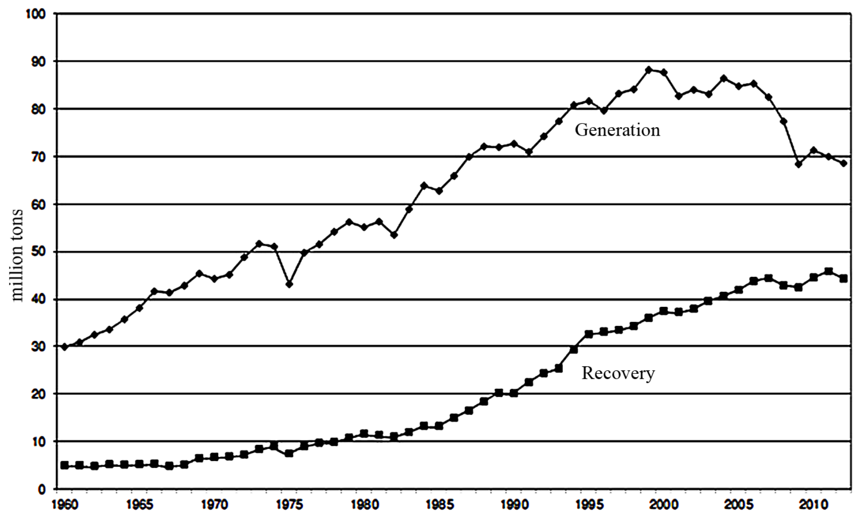
Recyclable Paper Materials

The domestic per capita consumption of board and paper in South Asia and India is 53kg,11kg and 6.5 kg respectively (Pati, Vrat et al. 2008). Paper as a renewable source material, is the major part of municipal solid waste such as white paper, mixed shredded paper, fresh newspaper, carton and brown packing paper, tetrapack (Agarwal, Singhmar et al. 2005). Based on the three years case study carried out by Metin et al. (2003) on 60 municipalities,in Turkey ;paper including cardboard is recognised as the main constituent in MSW. The savings of recycling for the paper products are smaller than non-renewable materials in the case of GHGs emission (Björklund and Finnveden 2005). On the other hand, paper quality, energy source at the mill and energy avoided by incineration process are the most effective elements in ranking between incineration and recycling method selection for paper (Figure 1).

Recyclable Aluminium and Glass

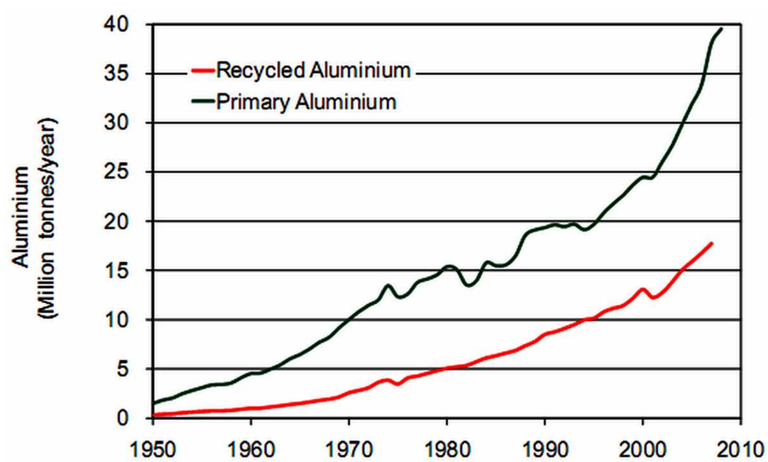
Aluminium production process consumes a majority source of power in society. In commercial area, aluminium and paper are the most recyclable solid waste. Nevertheless, in tourism area, putrescible material, such as aluminium and paper should be recycled(Diamadopoulos, Koutsantonakis et al. 1995). In municipal solid waste incineration, more than 90% of the aluminium and cooper is transferred to slag(Wäger, Eugster et al. 2005). This slag cab be used for cement production (Kikuchi 2001, Ferreira, Ribeiro et al. 2003). In many countries, zeolite is recognized as suitable absorbent for pollutant removal in environmental treatment process. However, this natural absorbent is not available in some countries. Therefor production of zeolite through the recycling process could be an acceptable opportunity for a win-win term. Zeolite synthesis (Yang and Yang 1998, Penilla, Bustos et al. 2003, Terzano, D'Alessandro et al. 2015), when compared to energy application and GHGs saving, the recycling is highly recommended. Bear and cold drink cans, deodorant scent cans and aluminium foils are the most commontypes of aluminium products in MSW (Agarwal, Singhmar et al. 2005, Wäger, Eugster et al. 2005). Glass recycling

Figure 1. Paper and Paperboard generation and recovery, 1960-2012 (Paper and Paperboard generation and recovery, 1960-2012. [report] (2012))



in material refinery facilities(MRF) consumes a much larger fraction of electricity (28%) when compared to other material recycling, which only consumes 10% of total electricity (Pressley, Levis et al. 2015). Amortized cost for each metric tone of waste input to MRF in ranges from 19.8 to 24.9 USD(Pressley, Levis et al. 2015) (Figure 2).

Figure 2. Worldwide evaluation of recycled and primary Aluminium (http://www.world-aluminium.org 2010)



Recycling, Greenhouse Gas (GHG) and Global Warming

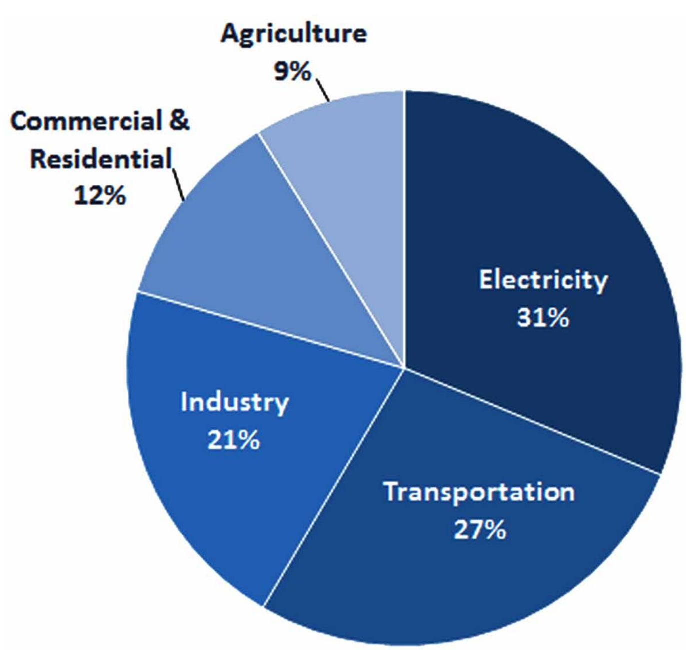
Greenhouse Gases

Greenhouse gases (GHG) contain carbon dioxide (CO_2), methane (CH_4),nitrous oxide(N_2O) and fluorinated gases. USA total emission of greenhouse gases in 2013 reach to 6.673 mllion tones CO_2 equivalent (USEPA 2013).

- **CO_2:** Coal, natural gas and oil burning, waste and cement manufactoring are some major sources for Carbone dioxide emission to atmosphere. Absorbtion by plant is the main removal mechanism for CO_2.
- **CH_4:** Production and transporting process of natural gas, coal and oil causes the emission of CH_4. Municipal solid waste landfilling and agricultural activities are other two major sources of CH_4.
- **N_2O:** Agricultural livestock, combustion of solid waste and fossil fuels are main sources of N_2O.
- **Fluorinated Gases:** The smallest quantity in emission but still is a powerful greenhouse gas that is emitted from industrial process. Figure 3 present main sources of GHGs emissions. Industrial processes, transportation and electricity consumption can be considered as the main sources of GHGs emission through various waste disposal methods.

Some of the important researches related to GHG, global warming and recycling indicate that recycling is an effective method for decreasing CO_2 gas emission and hence reducing global warming. Other researches were carried out by Astrup et al. (2009) on plastic recycling, Larsen et al. (2009) on glass recycling,Damgaard et al. (2009) on metals recycling, Laurijssen et al. (2010) on paper recycling

Figure 3. Sources of Greenhouse Gas Emissions (USEPA 2013)



and Kim and Song (2014) on wood recycling. Nowadays, most of the developing countries are not setting their municipal solid waste management system with specific view on energy recovery from waste in different process of MSW management, especially in disposing methods. This policy does not only allow us to produce energy, but also we can follow green technology in waste disposal, which saves us from greenhouse gases(Kothari, Tyagi et al. 2010, Nakata, Rodionov et al. 2010). Greenhouse gases contain carbon dioxide(76.7%), methane(14.37%) and nitroxide (7.9%), which are normally produced from anaerobic biodegradation of disposed wastes in landfill(Zuberi & Ali 2015). Based on Fotovat et al. (2015) and Yoshioka and Grause (2015), concentration on refuse drive fuel (RDF) production from landfill disposal system, incineration facilities or recycling process can be considered as suitable GHGs reduction method. Furthermore, Tan et al. (2014) researches show that integration landfill gas recovery as major waste-to-energy strategy and incineration as the minor WTE strategy could reach to comfortable GHGs reduction and energy potential. Another research carried out in African weather by Oyoo et al. (2014) also suggested that integrating resource recovery, anaerobic digesting, sewerage and landfilling is the best method for all environmental impact categories in comparison to traditional methods, maximizing landfilling and finally combining composting, landfilling, sewerage and resource recovery. In other words, recycling gives new life to material as well as save GHGs. According to Schott and Andersson (2015), 35% of food waste in municipal solid waste are avoidable. Consequently, this amount of food waste avoidance can help in reduction of GHGs. Based on the report ofVergara et al. (2015), textile informal reuse save largest GHGs and landfilling leads to highest emission of GHGs. Municipal Solid Waste disposal is not only a multi-complex process including MSW collection, transfer station locations, treatment policy, location of treatment plants, and recovering energy by waste to energy (WTE) system (Consonni, Giugliano et al. 2005), but also an effective ecofriendly sustainable GHGs reduction method (Cheng & Hu 2010). Global attention to air pollution and GHG caused establishment of national and continental regulars for prohibiting environmental impacts of incineration plants. Recently, Cheng and Hu (2010) presented emission limits of air pollutant materials from municipal solid waste incineration system in USA, EU and China in their review paper. Municipal solid waste disposal is a multi-complex process including MSW collection, transfer station locations, treatment policy, location of treatment plants, and recovering energy by waste to energy (WTE) system (Dewi, Koerner et al. 2010).This issue presented in Figure 4 as a schematic plan of management.

Recycling Efficiency

As opposed of the agricultural or industrial homogenous waste, municipal solid waste is the most complex stream (Wang & Nie 2001). For avoiding counterproductive results, establishing the new formal recycling method should have a clear picture from drawback and merits of informal recycling methods which already exist (Wilson, Velis et al. 2006). Informal recycling environmental impact as GHGs had been assessed in compare with industrialized and modernized formal recycling by Vergara et al. (2015) and their results indicate that informal recycling emit far fewer GHGs than formal system. A questioner study carried out by Lavee (2007) shows that recycling ranges from 10% to 80% . Other efficiency study carried out on 23 cases by Troschinetz and Mihelcic (2009) shows that average of recycling recovery in developing countries are 5% - 40%, in this research the average of MSW generation rate was 0.77 kg per person per day. Consequently, between about 40-300 grams of daily MSW could be recycled (Figure 5).

Figure 4. Collaboration web illustrating relationships among the 12 factors influencing sustainable recycling in developing countries (Troschinetz & Mihelcic 2009)

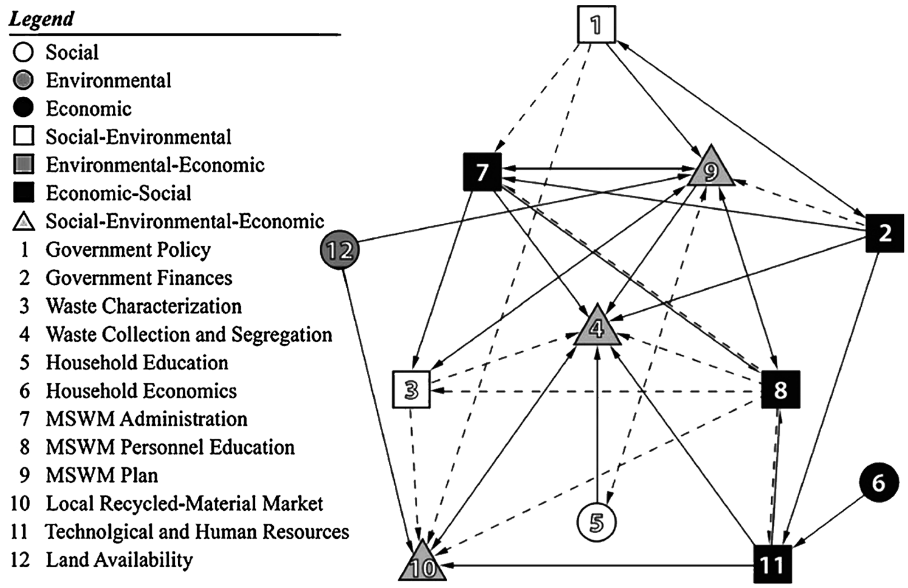
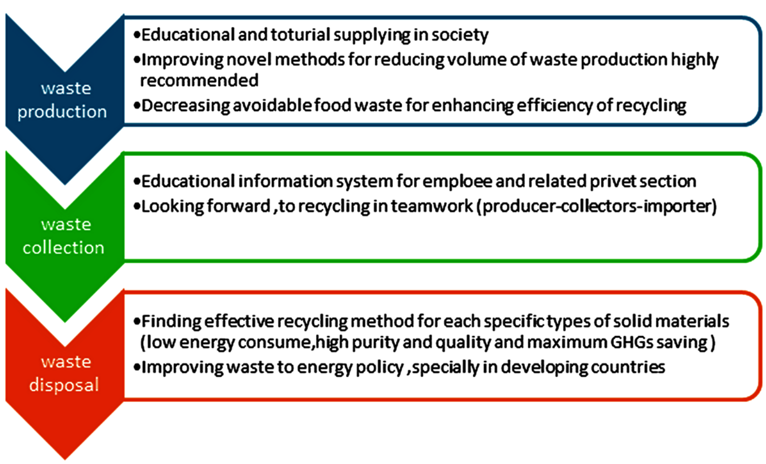


Figure 5. Diagram of critical effective elements in waste disposal (recycling)



WASTE INCINERATION

One of major process of waste management is waste incineration, which can reduce approximately 90% of waste volume. Japan, Germany, France, Sweden, Switzerland and Denmark are the countries in which 50% or more of the un-recycled waste goes to incineration process (Hjelmar 1996). This kind of waste disposal is carried out in developed countries. Furthermore, limited available and cost effective land for landfill or transporting system are critical elements in waste disposal by incineration method (Hjelmar 1996, Quina, Bordado et al. 2011). Developing countries are also going to be major operators of incineration. In China, there were 109 MSW incinerators till 2011 and treatment capacity of these plants reaches to 94414 (Yao, Kong et al. 2015). Taiwan as a developing country combined sanitary landfilling of MSW with incinerated residuals as a specific method (Gau & Chow, 1998). On one hand, based on the world bank report by Daniel and Perinaz (2012), MSW production will reach 2.2 billion tones in 2025. On the other hand, incineration technology is going to be the second most important means of MSW management strategy because of increasing MSW and merits of this method of waste disposal (YAN & WU 2003).

Incineration Drawback and Solution

Some kind of hazardous residues that are produced by incineration systems are boiler ash, fly ash, air pollution control (APC) and bottom ash. Heavy metals (Zn, Cr, Pb, Ni, As, Hg and Cu) and high amounts of soluble salts (K, Na, Ca and Cl) are specific characteristic of incinerated residues, which normally form leaching solutions. Incineration residues should also be considered as an air pollution source (Tu, Yu et al. 2010). Air pollution control (APC) residues, generated from municipal solid waste incinerator(MSWI), are classified as hazardous waste since they contain a lot of leachable metallic elements, soluble salts and organic compounds, hence should be disposed carefully (Reijnders 2005, Quina, Bordado et al. 2010). Furthermore, as a thermal treatment, incineration may produce polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans, which are highly toxic compounds(Fiedler 1996). MSW residues obtained from waste incineration should also be categorized as a hazardous waste and waste management in this part of waste disposal should be properly carried out (Li, Xiang et al. 2004). Based on the report of (Quina, Santos et al. 2008), solubility of APC in water is 24% higher than in 1/10 ratio of solid to liquid ratio which is the cause for its reduced utilization. For metal carbonation of APC residues which originate through natural aging from MSW incinerator, water content plays a critical role (He, Cao et al. 2006). There was a positive effect of pre-washing in chemical stabilization of MSW incineration by-products (APC) as reported by Quina et al. (2010). Also, water washing presented by Lin et al. (2011) as a suitable way for removing odor and environmentally apprehensive organic materials. Due to high content of soluble salts air pollutant control (APC) residues have been classified as "not allowed as building material" (Quina, Bordado et al. 2011). Therefore, pretreatment for removing soluble salts absolutely should be carried out. Aerobization of metallic elements which reach residues is possible, furthermore it doesn't lead to much dramatic increase of metallic elements in the leachate (Inanc, Inoue et al. 2007). Presence of high quantity of nitrite in municipal solid waste incinerator (MSWI) bottom ash was reported by Belevi and Moench (2000). Nowadays, Islam and Patel (2011) and Yang et al. (2014) have indicated that high concentration of metallic (Fe and Al) hydroxides and layered double hydroxides, which have high capacity for nitrite absorption, can solve the problem of nitrite in MSWI. Controlling pH will be an effective factor in removing organic matter but it has the disadvantage of nitrite reduction. Hence, using additive assistance (PO_4^{-3}), will be suitable for nitrite retention by formation of apatite(Yao, Kong et al. 2015). Dioxin contained in MSWI residue is another drawback, which makes it a hazardous potential waste. Humification of municipal solid waste incineration residue has high positive effect in decreasing dioxin content and it can be carried out through biological activities(Kim & Osako 2004).

Incineration Bottom and Fly ash Application

- Road construction in Denmark(Birgisdottir, Bhander et al. 2007).
- Ceramic tile body(Andreola, Barbieri et al. 2001).
- Incineration ash can use as co landfilling with cellulose for alkaline degradation of cellulose(Svensson, Berg et al. 2007).
- Geotechnical or construction offered by Tu et al. (2010) for incineration slag since structure of slag can immobilized heavy metals .
- Residual carbon of incinerator used for formation of dibenzofurans by using $Na^{37}Cl$ in USA(Addink & Altwicker 2001).
- Suitable for use as secondary constructional issue or applied in landfill disposal process with MSW(Youcai, Lijie et al. 2002).
- Applied as the liner, leachate drainage layer and protection layer in place of natural mineral such as till, gravel, sand and clay(Travar, Lidelöw et al. 2009, Su, Guo et al. 2013).
- Prohibitory application for nitrite immigration in the landfill(Yao, Kong et al. 2015).

There have been some researches, such as Lisk (1988), Durlak et al. (1997, and Hellweg (2001) on optimum operation management system and technical supplying through incineration process in thermal plants for decreasing hazardous emission. Nevertheless, environmental impact of fly/bottom ash is a concern for many researches. Table 2 presents related studies to environmental impact through incineration ash application.

Heavy Metals

Batteries are the main source for zinc, cadmium and nickel. Meanwhile, mercury content in batteries is nearly zero. So they could be found in sludge and incinerator ashes (Lemann, Walder et al. 1995). In the process of waste incineration, rare metals like Ag, Ga, Bi, In, Sb, Te, Sb, Pd and TI are volatilized in gaseous and/or chloride form. In the next step at melting furnace, fly ash goes to condensing while, Zr, Cr, Ni, Ta and V remain in the molten sludge (Jung & Osako 2007). Based on the report of Jung et al. (2004), a considerable amount of heavy metals have been distinguished to be lost as waste material in the land-filling of incineration residues. Due to the volatility of Pb and Zn, these low metallic elements are found in the bottom ash up to a third amount of these metals in the incinerator. Cd will be found in the fly ash, where as Fe, Cu, Al, and Cr will be found in the bottom ash (Jung, Matsuto et al. 2004).

Table 2. Related studies to environmental impact through incineration ash application

Location	Effective impact	Reference
China	Incineration ash application in asphalt	(Xue, Hou et al. 2009)
France	Incineration ash application in cement	(Aubert, Husson et al. 2007)
Brazil	Comparing incineration and landfilling environmental impact	(Mendes, Aramaki et al. 2004)
Italy	Comparing incineration and landfilling and sorting strategy	(Cherubini, Bargigli et al. 2009)
Denmark	Road constructed with incineration ash	(Birgisdottir, Pihl et al. 2006)
Spain	Toxic organic compounds reminding in soil and grown plants	(Domingo, Schuhmacher et al. 2000)

Shimaoka et al. (2007) researched on determining the alterations due to weathering in 2-10 years old landfill site in which MSW incineration residues have been applied as landfill. Based on the research, not only did Al, Mn and Fe increased by depth of landfill, but also in 8-10 years old landfill, concentration of Al, Zn, Pb and Fe in pH 6-10 was lower than the fresh residues. Hydration was presented as the reason for stabilization of these elements. Figure 6 show the XRF composition of MSWI residues in fresh and land-filled residues.

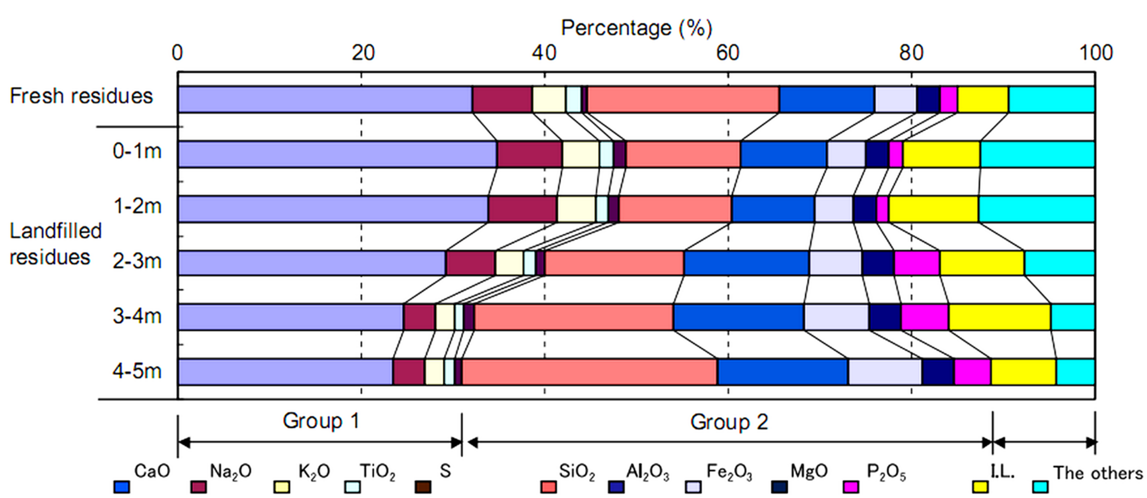
Dissolved Organic Matter

Organic carbon in waste incineration process is converted to CO_2 (98-99%) or transferred to bottom ash (1-2%) or (0.1-0.4%) to boiler ash APC residues(Ferrari, Belevi et al. 2002). Based on the research of (Seo, Kim et al. 2007) fluorophores, an aromatic amino acid in dissolved organic matter fraction, could be considered as an important effective factor in the complexation process with the pollutant materials. Residual organics have received far less attention in comparison to metallic elements as counterpart. Aromatic amines, antrhracene, carboxylic acid diethylamide, bromo–N-(4-bromo-2-chlorophenyl)-propanamide) and other aromatic compound are major odorous compounds in incinerator bottom ash (Lin, Yen et al. 2010; Ferrari, Belevi et al. 2002).

MUNICIPAL SOLID WASTE COMPOSTING PROCESS

Municipal solid waste is by far the largest source of human made organic waste, which has the capacity of composting, based on the document presented by (Epstein 2011). According to the research, there was a publication of report on compost application in year of 1888. Composting process is a natural process in our environment. In fact, industrial composting is an expert of advanced copy of natural biodegradation of organic material, which is specialized by mechanical and electronic equipments. After recycling

Figure 6. Major compositions (>1%)in the fresh and landfilled MSWI residues determined by XRF (Shimaoka, Zhang et al. 2007)



process, edible waste which has high quantity of organic matter, could be used in the composting system; an intermediate disposal method, which converts high quality of organic manure. Furthermore, this process could decrease the volume of MSW (Stentiford 1996, Epstein 2011).

Microbial and Thermal Characterization

Composting is a microbiological singularity that highly depends on temperature fluctuation within the windrows. The temperature through a composting mass regulates the rate at which many of the biological procedures, play a specific selective role on the advancement and the succession of the composting microbiological communities (Hassen, Belguith et al. 2001, Epstein 2011). Controlling the process of composting fundamentally depends on the Oxygen rate, which has to be kept at optimum level. Generally in biological terms, operating temperature should be more than 55 ^{o} C for highest sanitation, 45 to 55 ^{o} C for achieving maximum biodegradation ratio and 34 to 40 ^{o} C for the lowest diversity of microbial communities (Stentiford 1996) . Three major steps, which can be distinguished in a schematic aerobic composting process, are: (i) mesophilic phase, (ii) thermophilic phase and finally (iii) a cooling phase. Thermophilic and mesophilic are basically effective temperature regime throughout the composting process. Thermophilic condition could control herb seeds and pathogen. Mesophilic situation is prepared to finally reach mature stable compost. Mesophilic condition provides optimum temperature for rapid and suitable biological decomposition of organic materials(Epstein 2011). Nowadays, compost plant construction and management are well developed and there are many advanced composting system for operation and application. The future of this technique was presented as organic fiber production from unsorted MSW (Quirós, Gabarrell et al. 2014),producing higher agronomic value compost (Awasthi, Pandey, & Khan, 2014). Meanwhile, composition of municipal solid waste plays a major role in the management of waste. In Table 3 composition of MSW in some parts of the world, USA, China, Malaysia, and Gambia are presented.

Table 3. MSW composition in New York (MacBride 2014), Hangzhou China (Chi, Dong et al. 2014), (Sanneh, Hu et al. 2011) and Kuala Lumpur Malaysia (Saeed, Hassan et al. 2009)

Component	New York USA	Hangzhou China	Greater Banjul Area Gambia	Kuala Lumpur Malaysia
Food waste	26.54%	58.15%	32.44%	57%
Paper	23.32%	13.27%	9.19%	17%
Plastics	15.01%	18.81%	-----	15%
Textiles	8.42%	1.47%	2.25%	1%
Glass	2.6%	2.73%	1.48%	1%
Metals	4.06%	0.96%	1.40%	2%
Wood	4.35%	2.61%	2.35%	2.61%
Slag/Sand	-----	-----	48.44%	2%
Electronic	0.97%	-----	-----	-----
Fine, organic	10.4%	1+5%	-----	-----
Other	4.26%	-----	-----	-----
Total/average	100%	100%	100%	100%

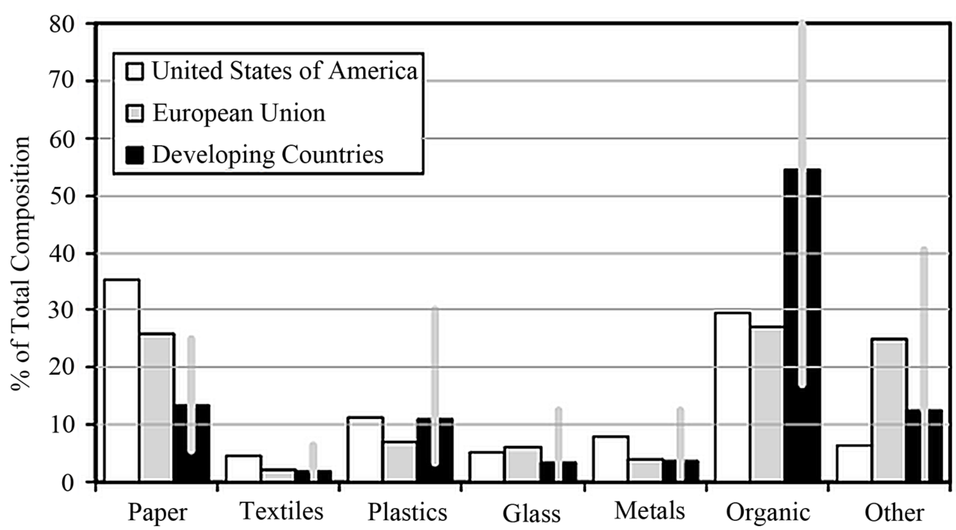
Organic Fertilizer Production for Agricultural Application

Composting is growing as a green technology and the application of MSW compost as organic manure in different agricultural system has a historical background, same as the composting of municipal solid waste. These two parallel lines are going fast together. The quality of municipal solid waste compost highly depends on the waste composition, which usually correlated to the economy and developing factors of the production origin. Figure 7 shows the composition of MSW in developed countries and average of 19 developing countries.

Horticulture science is a well-known part of agriculture, which has many operations and applications in human society and environment such as landscaping, floriculture parks, grass area for playground and countryside vegetable and fruit garden. This could be considered as the main applier of municipal solid waste compost. Different kinds of compost application in horticulture are presented by (Stoffella & Kahn 2001). (Hargreaves, Adl et al. 2008) present a review on agricultural application of MSW compost. Based on the research of (Garcıa-Gil, Plaza et al. 2000), for long term application of MSW compost, heavy metal content and other toxic material should be considered as an aspect of quality control. Some of the positive effects of MSW compost are mentioned in the following points:

- Improving soil biochemical and biological properties (Garcıa-Gil, Plaza et al. 2000)
- Increasing total N and C, furthermore enhancing nitrate reeducates and de-hydrogenase activities in soil (Crecchio, Curci et al. 2001)
- Improving physical and chemical properties of soil (Shiralipour, McConnell et al. 1992, Giannakis, Kourgialas et al. 2014)
- Increasing yield of vegetables comparing chemical fertilizers (Mkhabela & Warman 2005).

Figure 7. Comparison of MSW composition of United States and European Union in compare with the average of 19 developing countries (Troschinetz & Mihelcic 2009)



- Better seedling emergence for tomato, pepper and cucumber comparing commercial peat (Roe, Stoffella et al. 1997)
- Suitable effect on adjusting plant hormones for cultivation of some forage species (Ouni, Albacete et al. 2014)

In fact, due to the materials departure and waste string as well as lack of nutrients and high level heavy metals, composting dropped to <4% in present time from 17% in 2001(YAN & WU, 2003). Composting of municipal solid waste has some drawback as follows:

- This kind of waste disposal needs size reduction and waste separation before starting
- Volume of produced organic manure is disproportionately large and quality is low
- This organic fertilizer may cause many pathogens and heavy metals in soil(Ayari, Hamdi et al. 2010).
- Since compost is bio manure so application in public area of cities and landscape may cause to odor and bioaerosol problem
- A product should be marketed (Epstein 2011).

ENVIRONMENTAL IMPACT

Waste disposal is one of the most important parts of waste management, which has a critical effect on our environment. On one hand, waste disposal methods reduce the volume and hazardous effects of our municipality (agricultural, industrial and municipal) waste, on the other hands, this part of waste disposing will produce other byproducts which are hazardous or may cause higher environmental impacts(Smith, Brown et al. 2001). Some of the environmental impacts of waste disposal are presented in GHG emission explained in (Palmer, Sigman et al. 1997, Williams 2005). It reports odor, noise, traffic congestion, emission of carbon dioxide and other pollutions from all kinds of waste disposal. Report of (Hjelmar 1996) indicates that landfilling incineration bottom ash is less problematic in comparison to air pollution control residues. Based on the researches of Japanese team (Mendes, Aramaki et al. 2004) in Brazil, landfilling have higher environmental impact in comparison to incineration.

During Waste Incineration

- A complete overview carried out on incineration environmental impact by scientist team from Denmark, Australia, Germany, and Italy (Sabbas, Polettini et al. 2003) and they concentrated on salts, metals and greenhouse gases emissions in their studying.
- Odor, litter and dust problem during discharge, handling and transportation.
- Sub-micron particles contain heavy metals and metallic compounds.
- Nitrogen oxide which can form at the flame temperature.
- Incompletely combusted pyrolysis products may produce volatile organic compounds and carbon monoxide (Daskalopoulos, Badr et al. 1997).

During Waste Composting

As an organic fertilizer, municipal solid waste compost is usually applicable manure for enhancing soil's physicochemical properties. According to Hargreaves et al. (2008), MSW compost could be applied in agriculture as a safe fertilizer. Meanwhile, application of urban waste compost for humans and its environment hazards, were reviewed by Déportes et al. (1995) .Furthermore Lou and Nair (2009) reviewed the effect on greenhouse gases emission in application of MSW compost. Following notes are some of the specific researches on environmental impacts through composting MSW:

- Dust and aerosol particles, some microbes and odor to air (Iranpour, Cox et al. 2005)
- Leachate, from high content of moisture (60%- 65%) in compost, to water resources (Daskalopoulos, Badr et al. 1997).
- Volatile organic compounds (VOC) production in composting process(Brinton 1998).
- Emission of NH_4-N through the composting process(Komilis & Ham 2006, Pagans, Barrena et al. 2006).

During Waste Recycling

Recycling process take a place by construction, transportation, washing, chapping all of which needs electrical energy application and causes production of GHG as a specific industrial activity. Among all environmental impacts of recycling, one of the most important issues is direct human hazard or injury as following:

- Health risks for sorting and recycling process and de-inking recycled materials (Rigamonti, Grosso et al. 2009).
- Hepatitis B and C prevalence during the separation process (Tsovili, Rachiotis et al. 2014).
- Respiratory disorders throughthe recycling MSW (Abou-ElWafa, El-Bestar et al. 2014).
- Gastrointestinal, skin, musculoskeletal and respiratory problems observed in Municipality operators worker (El-Wahab, Eassa et al. 2014).

SOLUTIONS AND RECOMMENDATIONS

Civilization and industrialization are related and correlated to waste production in municipals. Waste disposal has many aspects and relationships to other parts of waste management. The processes of waste management start withthe waste generation and end with final landfilling. On one hand, municipalize going on to produce higher volumes of waste; while on the other hand, industrialization has another effective point in waste composition. Selecting an effective method for treatment or disposing MSW could give novel improvement in saving energy and reducing the drawbacks of produced waste. Meanwhile, concentration on decreasing volume of waste production with the educational system and promoting on the cultural background of any society will assist the sustainable environment. Not only, the economic circumstances, but also cost effective properties will have a significant effect on selecting favorite waste disposal method. Protecting the environment in green way method needs to avoid the production of hazardous waste or environmental impacts. Governmental policy is the most effective element as well as private section cooperation could lead us to eco-friendly methods of waste disposal. In other words, recycling is a major concern of waste disposal and is an important requirement for today. Nevertheless, in the next decades, there will be critical imperative activity. To sum it up, our future worlds are mostly going to incineration of municipal solid waste and land filling disposal method, so eco-friendly aspects of these methods will be the key to reaching green way of waste disposal. Meanwhile, professionally engineered, cost effective green technologies for specific recycling method have high value in researches.

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