Solid Waste Management

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Abstract— Nowadays climate change especially global warming is one of the serious environmental issues. The evidence of global warming has raised humans' concern regarding environmental problems, and a part of global warming results from inappropriate waste management. Waste is an important contributor to co_2 emissions in the world. It is therefore necessary to reduce the amount of biodegradable municipal waste going to land fill as to prevent or reduce the negative effects of land filled waste on the environmental and human health. There is a real need for alternative waste treatments to deal with the above requirements. The purpose of this research paper is to discover the best alternative treatment for reducing municipal waste going to land fill and to assess the alternative treatment from the view point of carbon foot print.

Key words: Solid Waste Management ,Recycling, Composting, Energy from Waste, Mechanical Biological Treatment, Pyrolysis , Higher Recycling, Land Fill and Green House Gas (GHG)

I. INTRODUCTION

People worry about global warming and want to contribute to the reduction of green house gases, because most countries in the world have been experiencing abnormal weather. Land fill is recognized as the waste management that makes the largest contributor to global warming. Country like UK compels to reduce the amount of biodegradable municipal waste going to land fill. Every municipal as a waste disposal authority (WDA) has a responsibility for appropriate facility installed, waste treatment and waste collection. Waste is not a large contributor to green house gas problem, it is also an area where doing the right thing for the environment. Five types of waste management make impacts on climate change and there are methane emissions by recycling and waste reduction, reduction in industrial energy use, and emissions by recycling and waste reductions, energy from waste, carbon sequestration in forests by decreased demand of virgin paper and energy used in long distance transport of waste. Almost all Municipal solid waste including organic waste goes to land fill and the results in a green house gas (GHG) including about 50 % methane. Gases are emitted from land fill which methane is most obvious, but also carbon dioxide and these contribute to global warming. According to Department of Food and Rural affairs (DEFRA),2007 , methane emissions from biodegradable waste in land fill account of 40% of all methane emissions and 3%of UK all green green house gas emissions. Methane is 23 times as damaging a green house gas as carbon dioxide.

II. CONTEXT OF THE RESEARCH PAPER

The term "Carbon "foot print" is now in the public domain and influences public behaviour towards global warming and climate change. The awareness has increased over the last few years and is used widely across the media, the government and in the business field (Wiedmann and Minx, 2007). Carbon footprint originated in the Ecological Footprint concept, introduced by Wackernagel (1996). It determines the biologically productive area essential to current consumption patterns taking into account technical and economic procedures (Holmberg et al 1999). It signifies a large amount of green house gas emissions related to climate change and connected to human behaviour including production and consumption activities (Wiedmann and Minx) .

III. AIM OF THE RESEARCH PAPER

(1) Aim of this research paper is to minimise the solid waste generated going to land fill by in-depth study of different Solid Waste Management Processes which can be practically adopted by Municipal Corporations.

IV. OBJECTIVES OF THE RESEARCH PAPER

(1) To determine the best alternative Solid Waste Treatment Process which gives lowest carbon emission in terms of off-set advantage.

V. LITERATURE SURVEY SUMMARY OF THE RESEARCH PAPERS

A. *Recycling – Different Authors:*

Recycling involves the process to collect the waste, sorting it, and producing new products made from used waste materials in order to reduce the consumption of raw materials (King et al 2006). Recycling is the third component of the Reduction, Re-use, and Recycling and Compositing, and is a key element of Waste Management (DEFRA 2007).

According to DEFRA (2007), in "Waste Strategy 2007" the Government set the following national targets to increase the recycling of household waste at five year interval

- To recycle or compost at least 40% of household waste
- To recycle or compost at least 45% of household waste
- To recycle or compost at least 50% of household waste

As they have an obligation to collect and dispose of municipal waste local authorities are responsible for delivering these targets.

Takeshi Shimotaya August 2008 terms of getting local people to cooperate communication is important. People felt recycling seems cumbersome and want to make recycling easier. CIWM (2005) states that, to overcome these obstacles, some good solutions are delivered. Following are representatives of solutions. In terms of communication, more education at all levels is needed. From the view point of policy issues, more streamlined and consistent enforcement of legislation and more regulations for recycling are needed.

On the basis of above, Timlett and Williams (2008) states that behavior change towards recycling is most significant, and methods and tools seem to play a significant role on behavioral change. They report on three projects each using a different behavior change approach. The project targets people to enhance participation in the recycling collection scheme and to diminish the number of non-targeted materials. The three projects are door stepping-based, incentives-based, and delivering personalized feedback to residents. Timlett and Williams (2008) carried out the door stepping project, the incentives project as part of DEFRA‟s Household Incentive scheme, and the feedback project. Effective ways to change social behavior about recycling would be setting gradually increased goals, providing motivational and instructional information, providing feedback, contracting behavior, displaying everyone's score, providing conditionality, and Face-to-face intervention. It is preferable that these useful ways which could change social behavior regarding recycling will be widely used to facilitate recycling.

According to Weitz et al (2002), recycling avoids using virgin materials and extracting raw materials, so is a very effective tool to reduce greenhouse gas emissions. Furthermore, recycling and composting contribute to reduce greenhouse gas emissions, such as methane, from the waste materials of the landfill. Weitz et al (2002) also states that the result of their study demonstrated that the release of greenhouse gas emissions can be significantly reduced by recycling and composting.

B. COMPOSTING BY DIFFERENT AUTHORS:

Composting is the process of decomposition of the organic, biodegradable fraction of waste to make a stable product including soil conditioners and growing material for plants (Williams 2005). Composting is also the third component of the waste hierarchy, a part of recycling, and is the key component of Waste Management (DEFRA 2007). Home owners have been stimulated by composting of garden and food waste (Williams 2005). Composting could gradually play a significant role in the reduction of perishable Municipal Solid Waste sent to landfill sites year by year and in helping local authorities to achieve the targets both on recycling and on diverting waste from landfill (DEFRA 2004). Composting generates sanitary, stable, and high humid substance which can be used in land. Using products made from compost process has a good impact on the soil structure, and also adds valuable organic substance, macro- and micro-nutrients, improves soil structure (CIWEM 2005).

Currently composting in the UK has three different types such as centralised composting, community composting, and home composting (DEFRA 2004). Centralised composting could be massively and commercially operated. For centralised composting operation, biodegradable wastes are collected from green waste at civic facilities, local authority parks and gardens, and kerbside collection site (DEFRA 2004).

Community composting is generally run by wide range of local groups and organizations (Slater 2007), and treats a large amount of biodegradable waste instead of treating it in their own gardens (DEFRA 2004).

Home composting is implemented in a garden of the house, and local authorities might provide composting bins to householders to facilitate composting, made from garden waste and kitchen waste (DEFRA 2004).

C. ENERGY FROM WASTE (EfW) BY DIFFERENT AUTHORS :

In terms of integrated waste management strategy, practicable recycling and composting and Energy from Waste (EfW) incineration have a beneficial effect, and EfW incineration plays significant role on municipal solid waste treatment（Porteous 2001).

Incineration can dispose of a wide variety of waste, but in most European countries, incineration of municipal solid waste is still not common treatment（Williams 2005）. EfW incinerators can be achieved using large-scale mixed waste mass burn systems or smaller modular burn systems (DEFRA 2004). Energy recovery from the municipal solid waste incineration has been an age-old concept（Williams 2005）. In general, electricity from waste is generated from high-temperature steam or the same is used for district heating schemes（Williams 2005）. In the UK, there are conventional EfW incineration operating plants (thirteen incinerators as of March 2004) (DEFRA 2004). The UK Waste Management Strategy needs to deliver the EfW incineration with more capacity, and with practicable recycling and composting in order to contribute to reduction of gas emission from landfill（Porteous 2001).

According to Williams (2005), waste incineration demonstrates several advantages over landfill below:

- Incineration can be located near the waste collection site. In some case, landfill sites are located near the waste generation, but they are insufficient, so waste needs to long distance transportation.
- Unlike landfill, Incineration does not produce methane. Methane as a greenhouse gas contributes significantly to global warming.
- Incineration of waste can produce a low cost energy without using fossil fuel.
- Incineration can be the best choice to dispose of many hazardous wastes including highly flammable, volatile, toxic, and infectious waste.
- However, Incineration of waste also has disadvantages below.
- In general, the capital cost for Incineration of waste is very high. The higher cost means long investment recovery.
- the high capital investment to Incineration of waste has an bad effect on the flexibility of waste

disposal options, because incineration of waste always needs to long-term waste disposal contracts.

- After extracting recyclable products, such as paper and plastics, from the waste, the waste sent to Incineration has low calorific value, so it may result in bad performance .

D. MECHANICAL BIOLOGICAL TREATMENT AUTHOR : DEFRA

Mechanical Biological Treatment (MBT) plants are used to treat residual municipal waste by a combination of mechanical and biological processes (DEFRA 2007). According to Environment Agency (2005), the mechanical process are shredding the waste, segregating ferrous and no-ferrous metals, classifying size, separating density, treating with heat and steam, screening, and reducing size of outputs. The biological processes involve both aerobic decomposition and anaerobic digestion. MBT is considered an intermediate treatment process, and has many possible configurations. MBT can produce several different outputs, such as metals, glass, a high heat value fraction, a fine and solid fraction.

Figure 1 below gives an illustration of the options for MBT. MBT can sort the waste first or undergo biological treatment first. ABT, Advanced Biological Treatment, involves both aerobic and anaerobic techniques (DEFRA 2007).

Figure 1 Mechanical Biological Treatment option

MBT technologies could be considered a useful tool to reduce society's reliance on landfill treatment (Juniper 2005). The first MBT plants were aimed at reducing residual waste sent to landfill with its accompanying effect on the environment (DEFRA 2007). CIWEM (2006) also states that MBT can help local authorities to meet the targets of

- Pre-treatment of municipal waste sent to landfill;
- avoiding non-biodegradable and biodegradable municipal solid waste being sent to landfill using mechanical sorting municipal solid waste for recycling and/or energy recovery as Refuse Derived Fuel (RDF);
- using the output of composting on land; and
- Transfer to a flammable biogas for energy recovery (DEFRA 2007).

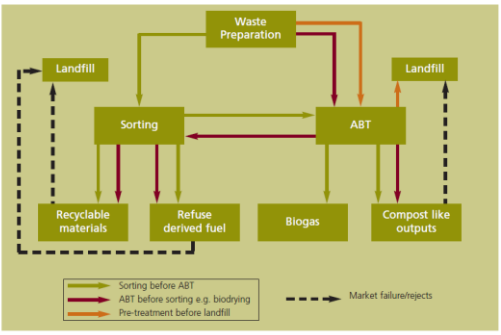

Fig. 1: showing Different Options - Mechanical Biological Treatment

E. PYROLYSIS AND GASIFICATION:

Pyrolysis, often incorporating gasification, is the medium temperature thermal degradation of organic waste in the absence of oxygen and under the action of heat to produce a carbonaceous char, oil and combustible gases (Williams 2005, DEFRA 2007). The process of Pyrolysis is no different to the process of charcoal production, and can pyrolyse only carbon based materials (DEFRA 2007). The process of Pyrolysis needs a heat source from the outside to keep the pyrolysis process going (DEFRA 2007). Thorough the process of pre-segregation, the majority of the nonorganic are removed from municipal solid waste for the pyrolysis operation, and through mechanical process the feedstock may be homogenized (DEFRA 2007). Pyrolysis may use a Refuse Derived Fuel (RDF) which already prepared in another appropriate process (DEFRA 2007). Pyrolysis takes place at relatively low temperatures, in range 300 and 850 centigrade, and Pyrolysis decomposes paper, plastics, and other organic derived materials to produce a gas (DEFRA 2007). A Pyrolisis Oil is produced from concentrate of this gas known as syngas (DEFRA 2007). The syngas is a mixture of gases, combustible constituents including carbon monoxide, hydrogen and methane, and condensable oils, waxes and tars (DEFRA 2007). The Pyrolysis Oil or the gas as a fuel may be utilized for engine oil or electricity generation. A solid residue, sometimes described as a char, producing from Pyrolysis process, is a combination of non-combustible materials and carbon (DEFRA 2007). The process conditions, especially temperature and heating rate, determine how much of each product is

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Figure 2 shows the characteristics of the main difference between pyrolysis, gasification, and incineration. According to Williams (2005), the amount of oxygen supplied to the thermal reactor is the main difference. There is no use of oxygen in the Pyrolysis process, and there is a limited use of oxygen during gasification. This means that complete burning of the combustible gases, such as carbon monoxide and hydrogen does not take place. For gasification the oxygen is supplied into the form of air, steam, or pure oxygen. Incineration, complete oxidising of the waste with surplus oxygen to generate carbon dioxide, water and ash, plus some other products such as metals, trace hydrocarbons, and acid gases.

Gasification is different from pyrolysis because the available carbon in the waste reacts with oxygen from air, steam or pure oxygen at high temperature in order to produce ash, and a gas and tar product (Williams 2005). Incomplete combustion takes place producing heat and a low to medium calorific value fuel gas (Williams 2005). Air (oxygen) is added but the amounts are not enough to allow the fuel to be completely oxidized (DEFRA 2007). Syngas

involving carbon monoxide, hydrogen and methane is the main product (DEFRA 2007).
Source : Williams (2005)

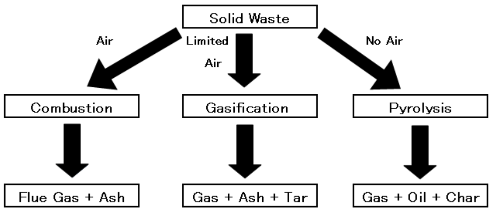

Fig. 2: Process Characterisation of incineration, gasification and pyrolysis .
Source : Williams (2005)

A solid residue of non-combustible materials, ash, containing a relatively low level of carbon is the other main product of gasification (DEFRA 2007).Gasification operates at a higher temperature range than Pyrolysis, typically above 650 centigrade, from 800 to 1,100 centigrade with air gasification, and from 1,000 to 1,400 centigrade with oxygen.

For air gasification calorific values of the product gas are low, in the region of 4 to 6 MJ/m3, and For oxygen gasification they are medium, in the region about 10 to 13 MJ/m3 (Bridgwater and Evans 1993; Williams 2005). Steam gasification is endothermic and steam as a supplement to oxygen gasification is normally added to control the temperature (Williams 2005). However, under pressure steam gasification is exothermic. A fuel gas of medium calorific value, approximately 15-20 MJ/m3 is produced by steam gasification with pressure up to 20 bar and temperatures of between 700 and 900 centigrade (Bridgwater and Evans 1993; Rampling 1993; Williams 2005) .

VI. CONCEPTS OF SOLID WASTE MANAGEMENT

Before discussing the Methodology of Research Paper , it will be appropriate to understand the terms involved:

(1) WASTE HIRERARCHY
(2) CONCEPT OF WASTE HIRERARCHY BY DEFRA
(3) INTREGRATED WASTE MANAGEMENT
(4) LIFE CYCLE ANALYSIS (LCA)
(5) WASTE HIERARCHY

The concept of a Hierarchy of waste management has been developed by the EU strategy on waste (Williams 2005). In 1975, the Waste Framework Directive originally provided the waste hierarchy which involved waste reduction, re-use, and recovery with disposal (Williams 2005). In the 1989 EU Community Strategy for Waste Management formally adopted the waste hierarchy (Gervais 2002). The waste hierarchy provides order for the best environmental options which have least impact on environment, and supports sustainable waste management (Waste not Want not 2002). According to Waste not Want not (2002), in their hierarchy (see Figure3) the order of the best options for the environment are reducing waste, re-use to products and materials, recovering value from waste, such as recycling, composting, and energy from waste, and disposal, landfill. The shape of the waste hierarchy takin into account current

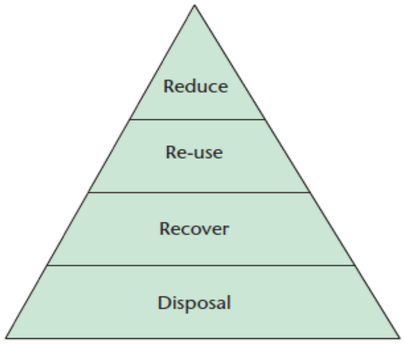

Fig. 3: showing the triangle of Waste Hirerarchy

treatment rate, such as recycling, composting, and landfill rate, seems to be the triangle shown in Figure 3

Figure 3 The Waste Hierarchy Source: Waste not want not (2002) .

(1) CONCEPT OF WASTE HIRRACHY BY DEFRA

Waste not Want not (2002) has also more detailed versions of the hierarchy. However, DEFRA (2007) provides the waste hierarchy below as a target for waste management (See Figure 4)
Figure 4 The Waste Hierarchy Source : DEFRA (2007)

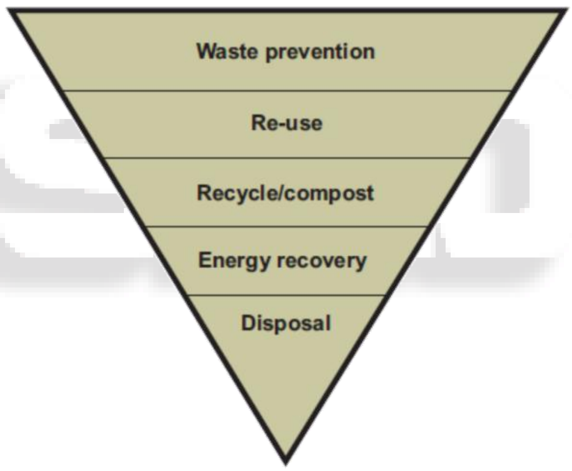

Fig. 4 : Showing the inverted triangle of waste hireracy , Source DEFRA

DEFRA (2007) states that the order of the waste hierarchy should be: Waste prevention (Reduction), Re-use, Recycling and composting. Recovery (Energy from Waste), and Disposal (landfill) (DEFRA 2007), and the shape of the waste hierarchy taking into consideration future treatment rate, such as recycling, composting, and landfill rate, should be an inverted triangle like that shown in Figure 4
Figure 5 Life cycle Source : DEFRA (2007)

To achieve the inverted triangular waste hierarchy from "Waste Strategy 2007", life- cycle thinking should be needed. The main stages of the life-cycle are shown in Figure 5

Policy should give the good direction to reduce environmental impacts of products, materials and sectors from the view point of life-cycle thinking. Policies involving modification of social

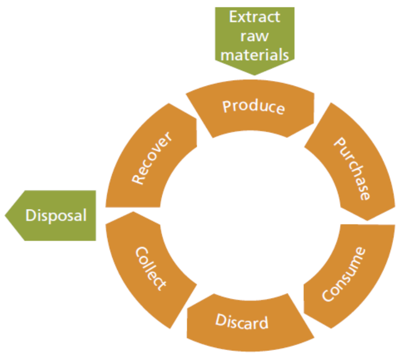

Fig. 5: Life Cycle Components as defined by DEFRA

behaviour in terms of life-cycle can contribute to waste reduction, the highest ranking priority waste hierarchy (DEFRA 2007). In terms of life-cycle the significant points of the influence by the Policy are:

- Extract – materials selection obtained from the earth, the way of those material extraction, and the way of those material use
- Produce – making and selling products generating less waste over their lifecycle and meeting prevention and recycling targets by designers, manufacturers and retailers
- Purchase – choice of more sustainable products and services by consumers and procurement professionals
- Consume – consumption patterns for waste prevention
- Discard –the decision to repair, re-use, or sorting for recycling instead of landfill bin
- Collect – framework of the most effective collection
- Recover – sorting waste for the technical capability and capacity of recycling and waste grows size year after year, and energy recovery, re-use market, remanufacturing and recycled goods
- Dispose –the reduction of waste sent to landfill and other options

As stated above, policy which should support the waste hierarchy and which has an influence on social behaviour could play a significant role in waste management.

(2) INTEGRATED WASTE MANAGEMENT

Waste treatment and waste disposal have developed from widespread uncontrolled dumping to a sophisticated management discipline incorporating a range of options (Williams 2005). Integrated Waste Management has been defined as a system dealing with all solid waste materials types and all solid waste sources, and taking an overall systems approach (McDougal and Hruska 2000).

Integrated waste management involves different treatment and disposal options, such as waste reduction, re-use, recycling, landfill, incineration, pyrolysis, gasification, composting, and anaerobic digestion (Williams 2005). However, integration means that each treatment and disposal option undertakes a role, but that overall waste management system is usually required to manage all wastes in an environmentally and economically sustainable way (McDougal and Hruska 2000;White et al 1995).

Figure 6 The elements of integrated waste management. Shaded area represents waste-to-energy Source : White et al (1995)

In figure 6 the centre of an integrated waste management system is the waste collection and sorting, because this affects the waste treatment and disposal options (White et al 1995). In a material recycling facility the useable materials, such as paper, glass, and metals, could be removed from the waste (Williams 2005). The residual waste may then use for production of refuse derived fuel or combustion in an incinerator as energy from waste (Williams 2005). The waste in landfill sites may produce gas and energy generated from gas combustion, through anaerobic digestion to produce a gas or compost (Williams 2005). Almost always the waste treatment options need a final disposal route, landfill, for the residual product (Williams 2005). An integrated waste management system would involve one or more of the above treatment options (Williams 2005).

- Tchobanoglous et al (1993) listed the six functional elements of integrated waste management:
- Waste generation – assessment of a risings, and evaluation of waste reduction;
- Waste source elements – source separation, on-site storage of waste, home composting, and compaction;
- Waste Collection – collection of waste, and transport of waste;
- Separation and Processing – material recovery, energy recovery, and biodegradation processes;
- Transfer stations – transfer of waste to larger vehicles, transport of waste to separation and waste processing site;
- Final Disposal – landfill and land spreading.

In order to achieve waste management targets and goals, integrated waste management is also defined as the selection and application of appropriate techniques, technologies and management programmes (Tchobanoglous et al 1993)

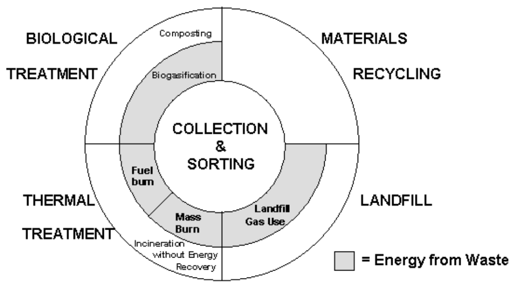

Fig. 6: Elements of Integrated Waste Management

VII. METHODOLOGY

(1) In framing the case for this research paper, it is decided to concentrate on discovering best waste treatment that would avoid generation of green house gases. Alternative solid waste management treatments which make a minimal impact on environment are:

(1) Recycling

(2) Composting
(3) Energy from waste (EfW)
(4) Mechanical Biological Treatment (MBT)
(5) Pyrolysis
(6) Gasification
(7) Combined Pyrolysis- Gasification
(8) Anaerobic Digestion (AD)
(9) Mechanical Heat Treatment

Adopted from Williams 2005.

Recycling can also decrease both direct and indirect green house gas emission (Korhonen and Dahlbo) (2000).

Step-I : After going through the careful study of composition of waste going to land fill site of Municipal Corporation under study, the percentage of materials which can be recycled, the percentage of materials which are biodegradable, the percentage of materials which can be separated by MBT process and the percentage of materials whjch can be incinerated are prima facia decided and the percentage of components of the above six treatment processes are fixed to quantify the green house gas like co_2.

Step-II Almost all the Municipal Corporations have past records of the solid waste collected in MT./ day for about 20 to 30 years and this can be utilised for growth factor. This growth is generally exponential . Municipal Corporations have also data for number of house holds and population figures for a particular year . The MC have target year for achieving ZERO WASTE. The above figures of house hold and population are projected for the zero waste year by geometrical formuala as available in Manual of Water supply and Treatment to arrive at quantification of co_2 emission for that particular year. The table containing the factors to arrive at the quantification of co_2 emission is discussed and shown below.The formula for arriving exponential growth is year wise is reproduced below:

$Y= a(1+r)^X$ where a is the initial quantity waste generated in a particular year, r is the growth / decay factor in percentage X the number of time interval that has passed and Y is the value of growth after a period.

Step- III To quantify co_2 gas emission, the first step is to calculate the various components of the solid waste treatment processes . These components are Recycling, Higher Recycling, Composting, Energy From Waste (EfW), Mechanical Biological Treatment (MBT) gasification, and Pyrolysis. These components are evaluated based on year wise quantity of growth which is calculated from the from the exponential formula as given in step- II.

Step-IV. To arrive at the quantification of co_2 gas emission of the said components as described in Step-III , basic factors are required. The rigorous search was made in journals, seminar papers and books, but no such factors are found for Indian Conditions. Bu the one prepared by DEFRA for UK Govt. are found and the table below is reproduced:

Process	Release	Paper/Card	Kitchen Waste	Garden Waste	Textiles	Fines	Misc. Combustible
Energy from Waste Incineration	Direct/Non UK	-392.18	-123.59	-123.59	218.56	132.42	201.58
Gasification	Direct/Non UK	-354.9	-70.2	-70.2	248.9	185.8	232.9
MBT with RDF combustion	Direct/Non UK	-334.7	-71.1	-71.1	97	122.9	86
Landfill	Direct/Non UK	272.25	121.36	121.36	171.32	61.41	165.33
Recycling off set	Direct/Non UK	-496			-7869		
Composting	Direct/Non UK		-16.2	-16.2			

Process	Release	Misc. Non-Combustible	Ferrous Metals	Non-Ferrous Metals	Glass	Plastic Dense	Plastic Film
Energy from Waste Incineration	Direct/Non UK	41.49	-414	-11614	-45.42	1117.72	990.01
Gasification	Direct/Non UK	96.9	-354	-11553	12.5	1125	1005.3
MBT with RDF combustion	Direct/Non UK	60	-366	-11566	2.3	680.2	600.4
Landfill	Direct/Non UK	32.46	3.36	3.36	6.46	3.36	3.36
Recycling off set	Direct/Non UK		-434	-11634	-762	-2324	-1586
Composting	Direct/Non UK						

Fig. 7: Factors to be adopted for co_2 gas emission

The above factors are used to quantify co_2 gas emission. Similarly for house hold and travel co_2 gas emission following table as prepared DEFRA by for UK GOVT. is to be used until factors for Indian Conditions are available.

National Average Direct Emissions	Household kg CO_2	Individual kg CO_2	%
Home	4,569	2,004	44.70%
Appliances	1,556	683	15.20%
Travel	4,096	1,796	40.10%
TOTAL	10,221	4,483	100.00%

Fig. 8: Factors to be adopted for house hold co_2 gas emission

VIII. CONCLUSIONS AND RECOMMENDATIONS

(1) After quantifying, the co_2 gas emission of the components of the above stated solid waste treatment processes using the factors as shown in above table, it is found that the treatment process with recycling, energy from waste (EfW) and composting gives the off-set advantage to a maximum and is recommended to be adopted by Municipal Corporation. The Ahmedabad Municipal Corporation has retained a private agency to utilise the components of the above process to produce energy. Likewise other Corporations can retain this type of agency to produce energy. This will help in producing energy.

(2) EU Landfill Directive The European Commission introduced the Waste Landfill Directive to reduce greenhouse gases and risk to human health. According to Williams (2005, pp174), "The European Commission regards landfilling of waste as the least favourable option, due to the fact that land filling does not make use of waste as a resource and may result in substantial negative impacts on the environment". "The European Commission have identified "emissions of hazardous substances to soil and groundwater, emissions of methane into the atmosphere, dust, noise, explosion risks and deterioration of land" as potential significant environmental impacts from the land filling of waste (Williams 2005,pp174)." Consequently, to reduce pollution from landfill which may have effects on the environment, such as surface water, soil and air quality, all of which will affect humans. Strict requirements for waste landfill were presented by the Waste Landfill Directive (1999) (Williams 2005). Williams (2005, pp174) also states that; "The European Community has a strategy, in relation to international climate change agreements to reduce the emissions of greenhouse gases". Therefore, a reduction of the amount of biodegradable waste sent to landfill to 75% of the 1995 levels by 2016 was established as an objective by the Waste Landfill Directive in order that methane and carbon dioxide emissions produced from landfill sites are reduced(Williams 2005). This directive is recommended for adopting in Municcipal Corporations of this country.

(3) The Landfill Allowance Trading Scheme (LATS)

According to DEFRA (2005), EU Landfill Directive requires the UK to reduce the amount of Biodegradable Municipal Waste (BMW) going to landfill because of contribution to prevent or reduce the negative effects of landfilled waste on the environment and human health. The Landfill Allowance Trading Scheme (LATS) is a tool to achieve the Directive targets (DEFRA 2005).

The Waste and Emissions Trading Act (2003) provides the legal frame work for the LATS and for the allocation of tradable landfill allowances to each waste disposal authority (WDA) in England (DEFRA 2005). Local Authorities can use LATS which has been developed as the revolutionary means to reduce the amount of BMW sent to landfill in the most cost effective way (DEFRA 2005).

(4) Landfill Tax According to Martin and Scott (2003), in October 1996 the UK landfill tax was implemented. There are two principle objectives of the tax:

- The UK landfill tax was aimed at applying an appropriate cost for the disposal of waste sent to landfill. It was commonly believed that the cost of landfill was very low compared with other European countries. However, the early cost estimates did not take account of the social costs or the environmental impacts.
- A second aim was to encourage sustainable waste management. Increases in the cost of landfill would encourage the substitution of landfill waste treatment, by recycling, re-use and waste reduction. The landfill tax was aimed to focus the minds of waste management teams, so as to reduce waste growth, and encourage recovery of valuable materials.

According to DEFRA (2007), the landfill tax has become a successful tool in reducing waste sent to landfill and because of reduction of the total amount of waste sent to landfill. Landfill went down from about 96 million tonnes in 1997/98 to about 72 million tonnes in 2005/06, so reduction rate of waste sent to landfill would be about 25%. Continuous increase of landfill tax will provide financial incentives for businesses to focus more on waste reduction and recycling. Landfill tax is designed to force business to reduce waste and to use substitute waste treatment instead of landfill (DEFRA 2007).

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DO THE BEST AND LEAVE REST TO GOD A PROVERB

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