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ENERGY RECOVERY FROM MUNICIPAL SOLID WASTE IN DHAKA CITY

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Abstract There is a crucial demand of disposing the waste of densely populated Dhaka City in a systematic manner. The waste could provide a means to produce energy particularly the highly desired electricity. The study provides an opportunity to analyze the quality assessment of the waste and introduce a system that will enable to generate energy. It also describes the mitigation of environmental hazards those are affiliated with waste and its traditional management system.

INTRODUCTION

We all use energy everyday, for example, to heat and cool our homes, wash our cloths and cook our food. While we, as householders, know whether our own domestic heating and cooking facilities rely on gas or oil. We do not know how the electricity is generated. But we use energy to run lights, televisions and washing machines. In Bangladesh, electrical power is produced from a number of different sources including oil, gas and renewable. As consumers we have no way of knowing what fuel source is used to generate electricity and to supply to the national grid that we use in our homes, offices, shops and factories.

The power, which runs our household appliances, comes from fuel and the municipal waste can also be used as fuel.

OBJECTIVES

- To assess the waste quality and quantity.
- To find out the economic feasibility of energy recovery.

METHODOLOGY

- Literature review.
- Incineration plant visit.
- Secondary data collection
- Data analysis.

PROBLEM STATEMENT

About ten million people live in the Dhaka city, which has an area of 344 square kilometres. Estimates for solid waste generated in Dhaka city 3500 tons per day (Sinha and Enayetullah, 1997) and the disposal of solid waste require 110 hectares of land per year. It is expected that by the year 2015, the total waste generated in Dhaka city will be about 8000 tons per day. It will require 292 hectares of land for disposal per year. Bangladesh, a land scarce country, does not have physical space.

The indiscriminate disposal of solid waste in public places causes serious environmental hazards and health risks. Uncontrolled and open dumping also clogs the urban drainage system, causes water stagnant and threatens the contamination of water supply. Thus, the growing problems of solid waste in Dhaka City are posing increasing threats to the health of its residents.
There is a crucial demand of electricity for consuming in households, factories, industries and public institutions. However, the supply is inadequate due to scarcity of high cost fuel. Therefore, using the waste of city to produce electricity by means of incineration, can contribute considerably to resolve the problem.

INCINERATION OF WASTE FOR ENERGY RECOVERY

Incineration

Incineration is an established method of processing combustible wastes originating from household, commercial and industrial sources. The process aims to reduce volume of household and commercial wastes thereby providing significant savings in transport costs and landfill requirements. It also destroys the organic, biodegradable waste components. Thus it removes those responsible for landfill gas and leachate generated when untreated waste is landfilled.

The first incineration plant (waste to energy) was operating in Hamburg, Germany in 1895. Old incinerator was operating for only district heating. In the beginning of the nineties, an extensive conversion of waste incineration plants from heating generation to combined power and heating generation took place.

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Use Of Incineration In Europe

Incineration process is capital intensive and skilled manpower is required for operation and maintenance. Till now, full-scale incinerator is currently operating only in the cities of industrialised countries. According to waste 21 regulations, the ban on landfilling of waste suitable for incineration that increases the pressure on incineration in developed country.

In 18 European countries have 304 incineration facilities. 96% of this incinerator recovers energy from waste. On an annual basis, Europe has 50.2 million tonnes of capacity to treat household and related waste. (Source: ASSURRE profile, 2000)

Energy recovery from incineration

Total plant capacity in Europe based on incineration is 8800 MW. 70% of this energy is used for district heating and 30% is used for electricity generation. Types of energy produced vary between countries and it depends on optimum technology and local demand. The annual amount of energy generated from incineration is equivalent to the total electricity demand of Switzerland.

Variations in treatment cost between countries

Treatment costs vary widely between countries. It is from €25 to €30 per tonne in Denmark and Spain and up to €160 per tonne in Germany. Treatment costs are defined as (operating cost + residue disposal costs + overheads + depreciation + finance costs) minus (value of energy + material sales) but excluding profit, subsidies and taxes.

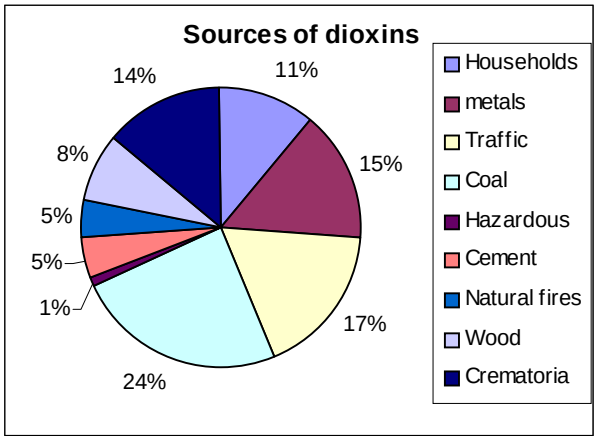
Energy from waste causes pollution

Waste is itself an emission. It is produced as a by-product of our daily life. Most of people often worry about dioxins from incineration plant. But dioxins are a family of about 200 compound of which just a few are hazardous to health. The majority of dioxins in the atmosphere are produced from different sources other than incineration. The sources include cigarette smoking, garden bonfires, forest fires, barbecues, transport and steel making. Some dioxins come into the energy from waste plant as part of the wastes and some are reformed after combustion. Typically 100000 tonnes of waste contains about 0.7 grams of dioxins. Majority of the dioxins is destroyed in the incineration process and less than 0.2 gram is emitted to air.

Table-1: Sources of dioxins in percentage

Component	Percentage of dioxins
Household waste	10
Metals	13
Traffic	15
Coal	21
Hazardous waste	1
Cement	4
Natural fires	4
Wood	7
Crematoria	12
Others	13

Source: SELCHP brochure, UK.

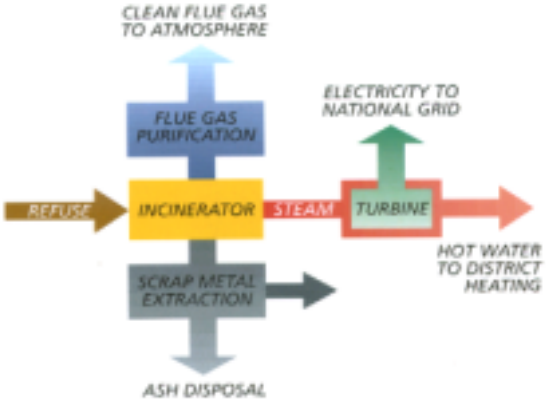


The Energy From Waste Process

The waste is treated as renewable resources, as well as a viable alternative to fossil fuel. The sources of primary energy are exhaustible. So, we should play a role how to get maximum benefit from the using of renewable sources. For example, over the past twenty years, awareness of the people regarding the recycling waste has been increased. Recyclable materials are being recycled. But we cannot recycle directly the most part of the waste. This part of the waste goes to the landfill whether it has value or not. This is how suitable sites for landfill are becoming more difficult to find. In this regard, incineration can give good solution. It is not only convert waste to energy but also recycles ferrous and non-ferrous metals. At the same time bottom ash would be separated. The ash produced from such plant can also be used as an inert aggregate in the construction industry, avoiding the need for disposal of the ash to landfill.

Incineration, burning process of the waste is strictly controlled under conditions. Potential harmful chemicals are destroyed at a certain temperature. The residues and flue gases are treated. Finally there is no any significant environmental impact.

Fig-1: Energy from waste process



Source: SELCHP brochure

Calorific value of waste fraction

Table-2: Calorific value

Component	Calorific value (dry matter) MJ/kg
Organic food waste	18
Animal waste	18
Newspaper and magazines	18
Tissue paper	18
Other clean paper and cardboard	17
Other dirty paper and cardboard	18
Plastic package	40
Other plastics	40
Flower and garden waste	8
Other waste for incineration	18
Glass package	0
Other glass	0
Iron and metal package	0
Other iron and metal	0
Other waste not for incineration	0

Source: Received by fax from „Videncenter for Affald“ DK-2830, Virum.

WASTE MANAGEMENT, QUANTITY AND QUALITY IN DHAKA CITY

Waste Management System In Dhaka City

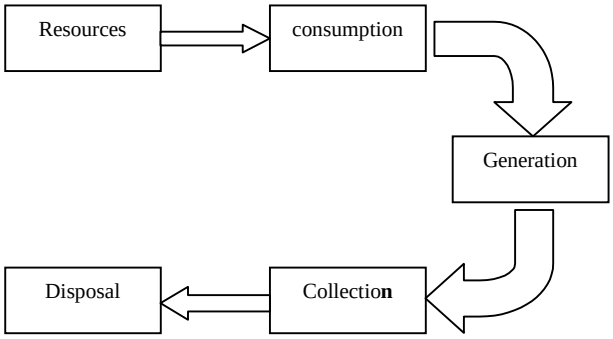
Solid waste management has traditionally been the preserve of local or municipal government. „ Once it is provided to some portion of a community, it benefits the overall public welfare, not only the residents that specially receive the service“(cointreau-levine, 1994). So it is not feasible to exclude from service who do not pay.

The Dhaka municipality established in 1864 and provided conservancy service for the city residents. In 1990, the municipality was up-graded to a city corporation and corporation continues to offer solid waste management service for its 344 square kilometre jurisdiction. The Dhaka municipal corporation ordinance, 1993 provides the legal basis for such services. But the ordinance does not impose any penalty for illegal and uncontrolled disposal of waste or littering of streets (Prof.B.A.Majumder, 1998)

The conservancy service was traditionally provided by manual labours called methors. Using bullock carts, they collected and disposed of mainly human excreta to trenching grounds. In 1983, bullock carts were replaced by motorised vehicles to carry the waste and to dispose it to dumping grounds. Hand carts are also used for collecting wastes from narrow streets where motorised vehicles can not enter.

Solid waste management in Dhaka city now covers only the collection of wastes from specific location and the dumping these in designated landfills. Furthermore, present waste management system involves no resource recovery. There is no recycling system of waste, except by the street children who extract the readily recyclable materials. They spread the waste around that increases the health risks and environmental hazards.

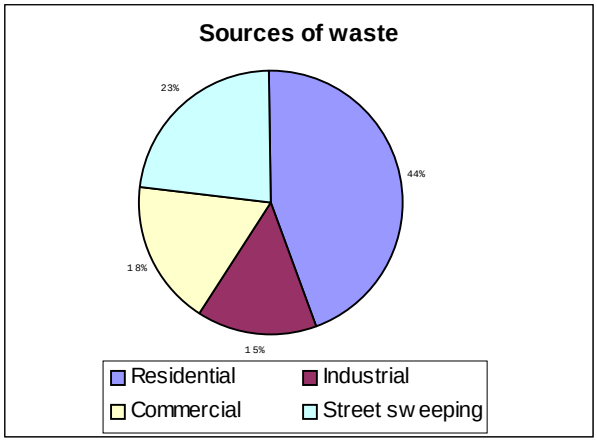
Fig-2: Flow diagram of waste management in Dhaka city. (Open organic loop)



Waste Generation

Waste generation rates are affected by socio-economic development, degree of industrialisation and climate. Generally, the greater the economic prosperity and the higher percentage of urban population, the greater amount of waste produced.

Low-income countries have the lowest waste generation rates, ranging from 0.4 to 0.9 kilogram per capita per day.



Composition Of The Waste

There are mainly three types of waste generated from three sector such as residential, commercial and industrial sector in the Dhaka city. Every sector generate different fraction of the waste. Food and vegetable waste, paper products, plastic, rubber, leather, garden waste and cloths are main fraction of the waste.

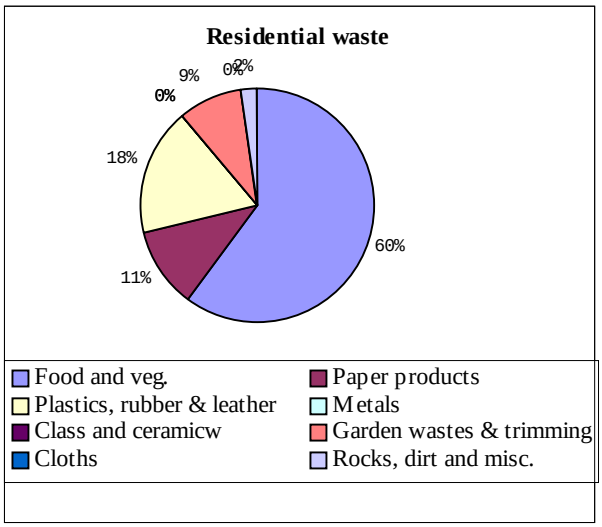
Table-3: Composition of solid waste of DCC

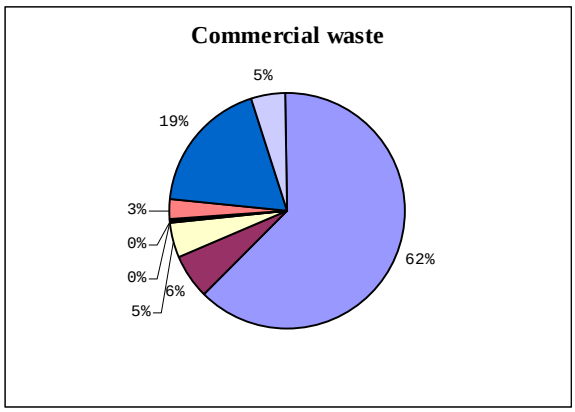
Component	Residential waste By weight (%)	Commercial waste By weight (%)	Industrial waste By weight (%)
Food and vegetable waste	59.91	62.05	26.37
Paper products	11.21	6.28	7.59
Plastics, rubber and leather	17.67	4.62	6.01
Metals	0.15	0.28	-
Glass and	-	0.37	-

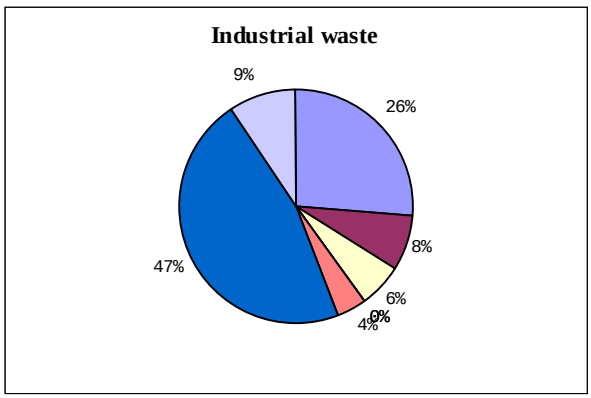
ceramics			
Garden wastes, tree trimming and straw	8.76	2.86	4.32
Wood	-	-	-
Cloths	-	18.93	46.20
Rocks, dirt and miscellaneous	2.30	4.62	9.49
Moisture content (%)	50	54	60

Source: world bank, 1998

Fig-3: Pie chart for different types of waste







ANALYSIS AND DISCUSSION

Technical Possibilities

(I) Calorific value of Haderslev plant's waste.

Calorific value of household waste is calculated 10.43 MJ/kg. Researcher has learnt from Mr.Harry Hansen, plant manager that at present the delivered waste for incineration is 9.5 to 10 MJ/kg. He also said that it was 7.5 to 8.5 MJ/kg in 1993 when plant started.

(II) Calorific value of the waste in Dhaka city

Calorific value of residential waste is calculated 9.20 MJ/kg. Calorific value of Industrial waste is calculated 5.67 MJ/kg. Calorific value of commercial waste is calculated 6.94 MJ/kg.

Since,

Residential waste = 44.2%. Industrial waste = 14.7%

Commercial waste = 17.7%. Street sweeping = 23.4%

Therefore, street sweeping is out of our consideration. Now new percentages of waste in individual sector are: Residential waste = 44.2/(44.2+14.7+17.7) =0.5770 = 57.70%. Industrial waste = 14.7/(44.2+14.7+17.7) =0.1919 = 19.19%. Commercial waste = 17.7/(44.2+14.7+17.7) =0.2311 = 23.11%.

Calorific value of the waste generated in the Dhaka city is 9.19*57.7%+5.67*19.19%+6.94*23.11% = 8.00 MJ/kg

This value is technically enough for incineration, while South East London Combined Heat and Power plant UK, is now burning the waste with the value of 8MJ/kg to 9MJ/kg. Of course, some extra fuels are necessary for burning of the waste of the Dhaka city since the moisture content of the waste is higher. Natural gas could be used as a extra fuel for burning the waste in Dhaka city while the country has own gas reserve.

Energy potential from the waste generated in the Dhaka city

The daily waste generation in Dhaka city is about 3500 tonnes per day. So, total waste generation in a year is about 1.28 million tonnes. Calorific value of waste = 8 MJ/kg=8000MJ/ton=2222.22kWh/ton. Specific power output per ton of waste at a thermqal efficiency 20%=0.2*2222.22=445kWh/ton. Potential of electric power plant capacity from the waste in Dhaka city= (1280000*445)/8000kW=71 MW.

Dhaka Electric Supply Authority (DESA) is responsible to supply electricity to the Dhaka city. At present in peak hour, demand of electricity of Dhaka Electric Supply Authority is 1200 MW to 1250 MW. But due to the difficulties of transmission and distribution, DESA is able to supply not more than 1000 MW. As a result in the summer every day load shedding is about 200 MW to 250 MW (the daily Ittefaq, Dhaka, 21.05.01). In this context, waste to energy could be a supportive system to be met the partial electricity demand.

Economical Feasibility

(A) Waste management cost per ton

(I) Waste management cost per ton through incineration in Haderslev, Denmark.
Total income=24483321 Kr., total expanses for the company=14880910Kr, total depreciasion and interest=18077682 Kr. And grand total expenses=329585922 Kr. Treatment cost = total expenses – (value of energy + material sales). But excluding subsidy and taxes. Treatment cost = 32 958 592 – 24 483 321 = 8 475 271 Kr. Amount of treated waste at Haderslev plant in 1999 is 63556 tonnes. Therefore treatment cost per ton = 8 475 271 Kr/63556 tonnes = 133.35 Kr./ton. (including electricity subsidy tax). Transportation cost per ton of waste is average 60 Kr./ton. Waste management cost (including electricity subsidy) is (133.33 + 60) Kr./ton of waste. I.e. it is about 193 Kr./ ton (approx.).
Total subsidy in 1999 from electricity selling from Danish government is 1579754 Kr. (Since Danish Government subsidy from electricity is 70 Kr./MWh and selling price of electricity from electric company is 288 Kr/MWh. Total selling price is (288+70)=358 Kr/MWh. Source: plant manager.). Total waste treated in the plant in 1999 is 63556 tonnes. Subsidy per ton of waste = 1 579 754 Kr./ 63556 tonnes = 24.86 Kr./ton Waste management cost (excluding subsidy) through incineration plant in Haderslev is about (193 +24.86) = 217.86 Kr/ton = **25.75 US $/ton**.

(II) Waste management cost per ton in Dhaka city:
From Iftekhar Enayetullah study it is learnt that the cost of waste management in the Dhaka city is **38 US $ / ton.**
In Dhaka city, waste management is defined as the collection of waste from different areas and disposal of the waste into specific landfill. Waste management service is without any resource recovery. So it is more expensive than in Denmark.

(B) Production cost of electricity

(I) Cost of electricity per kWh through incineration at Haderslev plant, Denmark:
Total expenses for the Electricity production is16 685 385 Kr. Total generated electricity in 1999 is 34248.9 MWh = 34248900 kWh. Therefore, unit cost of electricity production = 0.49 Kr./kWh = **0.058 US $ /kWh**

(II) Unit cost of electricity production in Dhaka city:
Bangladesh has own natural gas reserve. Electricity generation through gas turbine is the cheapest one in the country. Per unit cost of electricity is around TK. 0.70/kWh (Khan, S. The daily Star, 18.06.01).
Unit cost of electricity production = TK. 0.70 /kWh = **0.013 US $ / kWh.**

If it is considered in the context of only electricity production, then it is not economically viable. But considering the optimum energy utilisation and environmental implications it has importance. The plant can generate heat in winter and cooling in summer. The main air conditioning areas in Bangladesh are conference hall, hotels restaurants, cinema halls, office buildings, pharmaceutical factory, textile mills, food processing industry, fisheries industry etc. All these sectors are environmentally sensitive and directly related to the general population. Of course, creation of awareness are needed to the end energy user. In near future it may turn to be economically feasible in the context of generation of electricity, heat and cooling. But it needs more research and development.

Environmental Concern
Since the population is gradually increasing, waste generation rate is also increasing. It is expected that in 2015, the total waste generated in Dhaka city will be 8000 tonnes/day. The huge amount of waste will create great environmental pollution, such as air pollution, water pollution, health and sanitation problem.

Air pollution: Air pollution in Dhaka city has reached alarming level. Dhaka has become a „gas chamber“ for slow poisoning. During monsoon, open dumping and open pit for waste disposal pollute the air in the whole city. Sometimes the waste is openly half burnt and it produces unhygienic smell for human being. It attracts the unnecessary birds and dogs and destroys the outlook of surroundings.

Water pollution: Dhaka city is situated on the river of Buriganga. Stream and river are polluted easily by water from the waste in rainy season. Since the city is affected by flood at least two or three times in a year, water is very easily polluted. Furthermore, seepage water of waste contaminated the underground water.

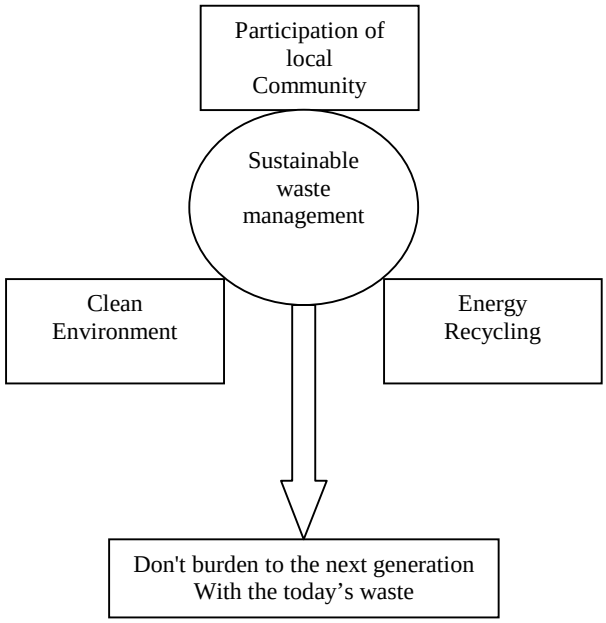
Health and sanitation: The indiscriminate disposal of municipal waste in public places causes serious environmental hazards and health risks. Most of the poorest section of the city duellers those who are living in the slums, are affected by many diseases. Water borne like skin diseases, diarrhoea and air borne like tuberculosis diseases are more prominent among different types of diseases. If the level of air pollution in Bangladesh's the four largest city (Dhaka, Chittagong, Khulna and Bogra) were reduced to the WHO standard, 15000 deaths would be avoided annually (Rahman, BEN discussion site). The economic cost of sickness and death will be the high amount of money, which could be contributed to increase the national GDP.

Energy from waste as well as incineration reduces overall greenhouse gas emissions in two ways. Firstly, it avoids methane and other emissions from waste disposed in landfill. Secondly, it generates lower co_2 emissions than traditional fuels. An analysis (Ecobalance, Washington, mat 1997) of co_2 equivalent emissions per kWh of electricity produce by energy from waste showed that the global warming potential of

energy from waste is less than coal, fuel and even natural gas.

Since the incineration reduces the volume of waste up to 90% and converts municipal waste to inactive form, incineration is itself a solution of environmental problem.

Fig-4: Impact of waste management



CONCLUSIONS

- The traditional waste management system is being done without any resource recovery.
- The calorific value of waste generated in the Dhaka city is 8 MJ/kg. Therefore municipal waste could be used as an alternative source of energy.
- The 1.28 million tonnes (3500 tones/day) of municipal waste, that only the capital city of Bangladesh, Dhaka generates every year. It could be used to produce about 71 MW of electricity.

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