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Developing the Waste Management System in Dhaka City, Bangladesh

Thesis

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Thesis Abstract

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Abstract: This thesis deals with the rising content of waste and the ever growing need to manage, dispose and sustain different kind of waste in Dhaka, Bangladesh. A concise description of the process by which, waste management is currently being done in a developing country and a comparison of the methods adopted by the developed countries. The aim of the thesis is to analyze and understand the difference in the methodology and to propose ways to achieve target percentages that are effective in an ecologically balanced environment. The proposed method and policies in this thesis will be in accordance to the best industry practices, for the purpose of which a benchmark is being set.

This study is based on both qualitative and quantitative method of data collection. Dhaka mega city waste management system can achieve its main goal by using proper planning, budgeting, controlling, benchmarking, sustainability and motivating citizen unawareness. A co-ordinate approach in proper treatment of wastes by the general population and the city corporation can create pollution free environment, job opportunities for a considerable number of people in this emerging megacity. The purpose of this paper is to focus and follow the Finnish waste management system as a benchmarking.

Keywords: Bangladesh, waste management, planning, benchmarking, sustainability.

ABBREVIATIONS

BDT Bangladesh Taka

BOD Bio Chemical Oxygen Demand

BOOT Build Own Operates Transfer

CO^2 Carbon dioxide

CH4 Methane Gas

DCC Dhaka City Corporation

DSCC Dhaka South City Corporation

DNCC Dhaka North City Corporation

EFQM European Foundation for Quality Management

EPA Environmental Protection Agency

GHG Green House Gas

IWM Integrated Waste Management

ISO9000 International Organizatio for Standardization

JICA Japan International Coopreration Agency

LCA Life Cycle Assesment

MSW Municipal Solid Waste

NGO Non Government Organization

PET Polyethylene Terephthalate

PPDF Pacific Provider Development Fund

RDF Refuse Derived Fuel.

STP Standard Temperature And Pressure

TCS Tata Consultancy Service

USEPA United States Environment Protection Agency

UNEP United Nations Environmental Programme

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1 INTRODUCTION

Bangladesh is a developing country and population of its capital, Dhaka is growing rapidly. Waste management has been a chronic problem since a longtime due to illiteracy and lack of information in a large section of population. Nowadays urban waste management is a big challenge and a serious issue for city authorities.

As long as the city would continue to grow, the amount of waste would grow proportionately and it has been posing a serious threat to the current waste management and disposal methods. Now days, waste Management system in the Dhaka City is developing gradually. Overall, the per capita generation varies from house to house depending on the economic status, food habit, age and gender of household members and seasons. On the other hand, the local government is trying to tackle the waste collection and segregation for disposal.

It can be assumed that Dhaka is a sub-standard city in terms of cleanliness because of lack of financial support for managing waste, less work force, old waste management system, technical difficulties, political corruption, and irresponsibility with unawareness of general public. The whole system is becoming a threat to city dwellers as the local government is not diligent enough in dealing with the situation for all urban areas equally. City corporation services that are responsible to deliver the cleanliness are already over-burdened, and cannot meet growing demand for urban services. As a result, an unhygienic and filthy living condition has been developing rapidly in all the urban areas including residential areas. To develop an efficient waste management system, the city corporation requires creating a waste sustainability program. The city corporation is looking for a safe and sustainable solution for the appropriate management of wastes.

1.1 Research problem and boundaries

Bangladesh has been known as a ‘Green Country' of World due to its natural reserves and greenery. The capital of Bangladesh, Dhaka is one of the fastest growing Mega cities in the world due to the economic boom in recent decade. As a

result of this there has been a rapid increase in the population and employment leading to high intensity consumerism, which ultimately creates a huge quantity of different kind wastes in the city. The average citizen is unaware of disposing garbage in a proper way leading to littering of waste in and around the city; the clean lines of the city have been facing acute hazardous conditions with severe environmental hazards as a consequence in this developing society. This paper illustrates the current status of developing waste management system, waste generation, and obstacles to properly manage waste in the city, which has been struggling with an improper and inadequate waste management system.

Population growth rate is rising rapidly in Dhaka city. Over population and enormous consumption leads to large quantity of waste generation. Every day, more and more people are moving from the rural areas and countryside to the urban area for economic reasons. The waste generation rate is increasing rapidly in Dhaka city but the waste processing system is still being managed with the old and outdated methods which are incompetent in managing the current situation with a huge backlog of waste in the outskirts of the city. One of the main industries in Dhaka is garment industry, which produces a lot of waste as a by-product, which cannot be managed with the orthodox techniques of the past. Other industrial sectors are also inefficient to process their respective wastes on the large scale and depend on the city corporation which is itself not equipped to manage the situation.

Furthermore, corruption and political ill-will is another major cause of concern in waste management system in Dhaka. Citizens are irresponsible and unaware about the correct method to dispose waste and consider the generated waste as a Valueless entity. Channelization of proper waste disposal is lacking because of negligence by the general population.

Waste management system in Dhaka mega city is being utilized as a sample for case study in a developing nation. The research will be primarily focused on the

different kinds of waste and their sustainability methods. The current waste management system in Dhaka mega city will be compared to a waste management system in a developed country like Finland. The methodology will be discussed in detail to ascertain the difference and suggestions to meet the specific requirements for better sustainability of the waste problem in Dhaka mega city. Although, the waste management system can never be achieved completely in any country in the world, it can be still achieved up to a very high standard, for example, like Finland. Hence, the objective of this thesis is to use waste management and sustainability methods in Finland as benchmark.

1.2 Research methodology

The research methodology means that, how all the information, data, has been collected to support the goal of this thesis. That means the collecting information facts and figures will be the correct and reliable. With this study, it is understood that a good research process would need a very thorough know-how of the subject which is being researched. It requires the detail knowledge of the system processes which are being followed at the time. A good research would depend on the following aspects –

- Knowledge of the research field.
- Identifying the research problem.
- Conceptualization of current situation.
- Research methodology.
- Data collection and analysis.
- Evaluation and recommendations, if any.

The research will be both qualitative and quantitative .The qualitative approach based on lot of questionnaire and all question about benchmarking company to achieve main information. Quantitative approach is about interview that provides future vision and present situation, roles, attitudes, behavior on real waste management system in Finland also in Dhaka City.

The research methods will be used to find out major problem of waste management system and suggest a good solution that will increase sustainable development in Dhaka City.

2 SUSTAINABLE WASTE MANAGEMENT

In this chapter, it has been described about sustainable waste management and characteristics of solid waste management in developing countries. Literature reviewed in the concept of integrated sustainable waste management and that sustainable system of solid waste management must be environmentally effective, economically affordable and socially acceptable. Moreover, in this chapter literature reviewed also the impact of wastes and future sustainability of waste management.

2.1 Waste and waste management

Waste is an issue produced by all and need to be tackled effectively in order to have a healthy environment. Waste generation increases proportionally with population expansion and economic development. Waste can simply be described as something that has no value, useless and want to be discarded by owner (Oluwaleye Michael, 2012). The author explains further from a financial point of view, that waste is an unwanted material that lacks financial value irregardless of the time or season because there is no demand for such item in the market place (Oluwaleye Michael, 2012).

According to EPA 2002, improperly managed solid waste poses a risk to human health and the environment. Uncontrolled dumping and improper waste handling causes a variety of problems, including contaminated water, attracting insects and rodents, and increasing flooding due to blocked drainage canals or gullies. In addition, it may result in safety hazards from fires or explosions. Improper waste management also increases greenhouse gas (GHG) emissions, which contribute to climate change, therefore, proper planning and implementing a comprehensive program for waste collection transport, and disposal along with activities to prevent or recycle waste can eliminate these problems in our society. (United States Environmental Protection Agency 5, 2002)

2.1.1 Characteristics of solid waste in developing countries

Over the years, the phrase “Municipal solid waste” (MSW) is a term usually applied to a heterogeneous collection of wastes produced in urban areas, the nature of which varies from region to region and as well have strong correlation with the level of economic development of such country.

2.1.2 Waste generation

Generally, the primary difference between wastes generated in developing nations and those generated in industrialized countries is the higher organic content characteristic of the former. The table below indicated the extent of difference in the quantity and composition of municipal solid wastes generated in several countries.

Location	Putres-cibles	Paper	Metals	Glass	Plastics, Rubber, Leather	Tex-tiles	Ceramics, Dust, Stones	Wt (g)/ cap/ day
Bangalore, India [1]	75.2	1.5	0.1	0.2	0.9	3.1	19.0	400
Manila, Philippines [2]	45.5	14.5	4.9	2.7	8.6	1.3	27.5	400
Asunción, Paraguay [2]	60.8	12.2	2.3	4.6	4.4	2.5	13.2	460
Seoul, Korea [3]	22.3	16.2	4.1	10.6	9.6	3.8	33.4[a]	2,000[a]
Vienna, Austria [4]	23.3	33.6	3.7	10.4	7.0	3.1	18.9[b]	1,180
Mexico City, Mexico [5]	59.8[c]	11.9	1.1	3.3	3.5	0.4	20.0	680
Paris, France [4]	16.3	40.9	3.2	9.4	8.4	4.4	17.4	1,430
Australia [7]	23.6	39.1	6.6	10.2	9.9		9.0	1,870
Sunnyvale, California, USA [6]	39.4[d]	40.8	3.5	4.4	9.6	1.0	1.3	2,000
Bexar County, Texas, USA [6]	43.8[d]	34.0	4.3	5.5	7.5	2.0	2.9	1,816

[a] Includes briquette ash (average).
[b] Includes “all others”.
[c] Includes small amounts of wood, hay, and straw.
[d] Includes garden waste.

Figure 1 Comparison of solid waste characterization worldwide (% wet wt) (adapted from Unep 2005)

According to the author, further explanation noted that Wastes generated in countries located in humid, tropical, and semitropical areas usually are characterized by a high concentration of plant debris; whereas those generated in areas subject to seasonal changes in temperature or those in which coal or wood are used for cooking and heating may contain an abundance of ash. The concentration of ash may be substantially higher during winter. Regardless of climatic differences, the wastes usually are more or less contaminated with night soil. These differences prevail even in wastes generated in large metropolitan areas of a developing country. (unep 2005).

Source	Typical waste generators	Types of solid wastes
Residential	Single and multifamily	Food, waste paper, plastics, textiles, wood, glass, consumer electronics, bottles, oils, household wastes.
Industrial	Light and heavy manufacturing	Housekeeping wastes, food, construction, hazardous wastes, special wastes
Commercial	Stores, hotels, restaurant, market,	Plastics, food, glass, metal,
Institution	School, hospital, prisons	Same as commercial
Municipal service process	Street cleaning, other residential area, water treatment plant. Heavy and light manufacturing, chemical plants, power plant.	Street sweepings, general waste from park. Industrial process wastes
All of the above should be included as municipal solid waste.		
Agriculture	crops dairies, farms	food wastes, agricultural wastes,

Figure 2: Sources and Types of Solid Wastes (Adopted from Urban Development Sector Unit East Asia and Pacific Region 1999)

2.1.3 Importance of a sound solid waste management program

An economically developing nation must pay adequate attention to solid waste management regardless of the its enthusiasm to accelerate industrial development

in order to avert severe penalty that may arise at a later time in the form of resources needlessly lost and a staggering adverse impact on the environment and on public health and safety. (Unep 2005).

The problem that will be impacted on the society is better avoided by acting fast at the appropriate time rather than contemplating of doing something with the waste at a later time, when the country may be in a better position to take appropriate measures. The greater the degradation of the environment, the greater is the effort required to restore its good quality. In summary, the effort to preserve or enhance environmental quality should at least be commensurate with that afforded to the attainment of advance in development. (Unep , 2005).

2.1.4 Environmental and health impacts

Improper handling of waste generated in any given society will automatically pose threat to human health and its environs. Inappropriate waste disposed on land or water that mostly occurred in some developing nations or among the less educated become toxic and infectious material that are dangerous to human health. These infectious materials can cause skin and blood infection, eye and respiratory infection as well as different diseases that result from the vector borne disease to name a few (The Ministry of Urban Development Government of India, [ref. 02 June 2012]).

Unless an organic waste management system is properly put in place, its adverse impact of improper disposal of waste will continue to create huge menace in any given society.

Research shows that, proper handling of waste; storage, collection, transportation, disposal of waste and the provision of information to the general public will avert the threat that could arise and as well create a conductive atmosphere to the general public.

A modern solid waste management program can be implemented and managed for a reasonable cost. This is an important fact because there are ample known

situations where solid waste management costs in developing countries are high and the level of service low. But, if the underlying reasons for these situations are analyzed, then one can see in many cases that cost-effective waste management systems would result if the identified deficiencies in the systems were remedied. (Unep 2005)

Integrated waste management

Integrated Waste Management (IWM) systems can describe as the combination of waste streams, waste collection, treatment and proper disposal methods, with the main purpose of achieving environmental benefit, economic optimization and societal acceptability.

The Key structures of IWM are as follows:

1. An overall approach

2. Uses a range of collection and treatment methods

3. Handles all materials in the waste stream

4. Environmentally effective

5. Economically affordable

6. Socially acceptable.

2.1.5 The basic requirements of waste management

Waste is an inevitable product of society. Solid waste management practices were primarily designed to avoid the adverse effects on public health that were being caused by the increase in amount generating and porous discarded method with no concrete and effective collection or disposal. Therefore, urgent need is required by the society to manage waste effectively and there are two fundamental steps to be taken; less waste, and then an effective system for managing the waste still produced. (Forbes et al, 2001)

The Basic Requirements of Waste Management

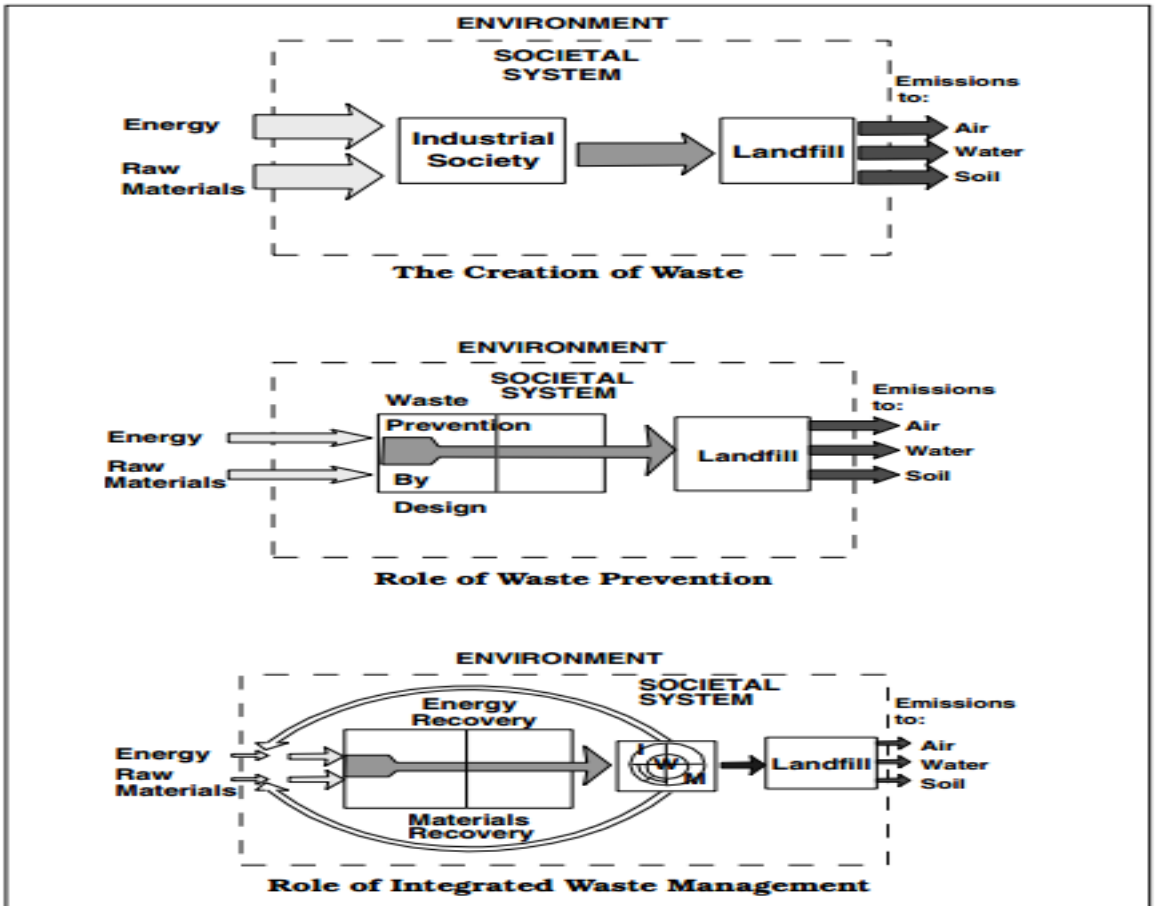

Figure 3: The respective roles of Waste Prevention and Integrated Waste Management. Life cycle studies, a 'system' is defined (with boundaries indicated by breaking lines). Energy and raw materials from the 'environment' are used in the system. Emissions, including solid waste, leave the system and enter the environment. (Forbes et al, 2001)

2.2 The concept of sustainable waste management

The main objective of Solid waste management systems is to ensure human health and safety. The environment must be safe for workers and safeguard public health by preventing the spread of disease. In addition to these prerequisites, a sustainable system for solid waste management must be environmentally effective, economically affordable and socially acceptable.

1. Environmentally effective: the society must not tolerate altitude of inappropriate disposal of solid waste in order to reduce or eradicate the hazardous effects (emissions to land, air and water, such as CO 2 , CH 4 , SOx, NOx, BOD, COD and heavy metals).

2. Economically affordable: every operational cost placed by the waste management system should be less and avoidable to the society. Mean that the waste management system should consider the living standard of people in any given community.

3. Socially acceptable: waste management system must work in accordance with moral and ethics which will aid cordial relationship with the society. This is likely to require an extensive dialogue with many different groups to inform and educate, develop trust and gain support. Provision of bins or containers for collection and sorting of waste is another means by which recycling can be effective in the communities.

On a clearer note, it is believed that it would be difficult to minimize three variables; cost, social acceptability and environmental burden – simultaneously. Therefore, a trade off will always is considered. (Forbes et al. 2001)

2.2.1 Characteristics of a Sustainable Waste Management system

A Sustainable Waste Management is considered to be a system that is likely to be integrated, market oriented, Flexible and socially acceptable. However the execution of such principles will vary on a regional basis and a key requirement to such phenomenon, is the ‘customer–supplier relationship’

An integrated system

The author also noted that the term ‘Integrated Waste Management’ has been frequently applied but rarely defined. Then further gives a comprehensively definition as a system for waste management that has control over:

All types of solid waste materials. The alternative of focusing on specific materials, either because of their ready recyclability (e.g. Aluminum) or their public profile (e.g. Plastics) is likely to be less effective, in both environmental and economic terms, than taking a multi-material approach.

All sources of solid waste. Wastes such as domestic, commercial, industrial, institutional, construction and agriculture; Hazardous waste needs to be dealt with within the system, but in a separate stream. Focusing on the source of a material (on packaging or domestic waste or industrial waste) is likely to be less productive than focusing on the nature of the material, regardless of its source. (Forbes, et al. 2001.)

A suggestion was given for an integrated system to include optimized waste collection system and efficient sorting, followed by one or more of the following options:

1. Materials recycling will require access to reprocessing facilities.
2. Biological treatment of organic materials will ideally produce marketable compost and also reduce volumes for disposal. Anaerobic digestion produces methane, that can be burned to release energy
3. Thermal treatment (such as incineration with energy recovery, burning of Refuse-Derived Fuel (RDF) and burning of Paper and Plastic-Derived Fuel (PPDF)) will reduce the volume, render residues inert and should include energy recovery.
4. Landfill. This can increase amenity via land reclamation, but a well-engineered site will at least minimize pollution and loss of amenity.

In order to effectively manage all solid waste generated in an environment, the above mention treatment options must be considered. (Forbes, et al. 2001).

Landfill is believed to be the only effective method that can manage all types of waste; since recycling, composting and thermal treatment all leave some residual material that needs to be landfilled. The research explains more that if the

appropriate conditions for the growth of aerobic and that of anaerobic bacteria occur in a landfill, the organic fraction of solid waste can be broken down. These relatively uncontrolled biological processes can take several years to start in a landfill and continue many decades after the landfill has been closed. Methane emissions arise from the breakdown of organic material and groundwater pollution may occur due to leaching of toxic materials from the solid waste. Landfilling operations also require large amounts of space. Use of the other options prior to landfilling can both divert significant parts of the waste stream and reduce the volume and improve the physical and chemical stability of the final residue. This will reduce both the space requirement and the environmental burdens of the landfill. (Forbes, et al.2001).

2.2.2 Implementing integrated waste management

The operations within any waste management system are clearly interconnected. For instance, the collection and sorting method adopted will influence the ability to recover materials or produce marketable compost. Similarly, recovery of materials from the waste stream may affect the viability of energy recovery schemes. Therefore, It is imperative to consider the entire waste management system in a holistic way. What is required is an overall system that is both economically and environmentally sustainable. Peter and Marina also cited that much effort that is contrary has been directed towards schemes focusing on individual technologies, e.g. recycling, or on materials from one source only (e.g. The German Green Dot system to collect packaging). From the perspective of the holistic waste management system, such schemes often involve duplication of efforts, making them both environmentally and economically ineffective. (Forbes et al. 2001).

➢ **Aim for the following:** • Environmental effectiveness: reduce environmental burdens • Economic affordability: drive costs out
➢ **The system should be:** • Integrated: in waste materials • in sources of waste • in collection methods • in treatment methods • anaerobic digestion • Composting • energy recovery • Landfill • Recycling • Market oriented: materials and energy must have end uses and generate income • Flexible: for constant improvement
➢ **Take care to:** • Define clear objectives • Design a total system against those objectives • Operate on a large enough scale
➢ Never stop looking for improvements in overall environmental performance and methods to lower operating costs. Remember that there is no perfect system.

Table 1: Designing a sustainable solid waste management system (Forbes, et al. 2001

However, holistic approach of waste management can be challenging due to many different compartments that it's encompasses. According to the author, collection of Municipal Solid Waste is usually the duty of local authorities, though may be contracted out to private waste management companies. Disposal often comes under the jurisdiction of another authority, and perhaps another private company. Different operators may contribute to recycling activities – in the case of material collection banks, these may be the material producers. Similarly, thermal

treatment, biological treatment and landfill operations may all be under the control of different operating companies. Each company or authority only has control of the waste handling within its operation, so what is the feasibility of taking an overall systems approach when no-one has control over the whole system?

The holistic approach has three main advantages:

1. It provides the holistic views of the waste management process. Such a view is essential for strategic planning. Handling of each waste stream separately is inefficient.

2. Environmentally, all waste management systems are part of the same system – the global ecosystem. Looking at the overall environmental burden of the system is the only rational approach; otherwise reductions in the environmental burdens of one part of the process may result in greater environmental burdens elsewhere.

3. Economically, each individual unit in the waste management chain should run at a profit, or at least break even. Therefore, within the boundaries controlled by each operator, the financial incomes must at least match the outgoings. By looking at the wider boundaries of the whole system, however, it is possible to determine whether the whole system operates efficiently and whether it could run at break even, or even at a profit. Only then can all the constituent parts be viable, provided that income is divided up appropriately in relation to costs. (Forbes, et al. 2001).

2.2.3 Current practice and future sustainability

The environment production cost and return is one of the significant problems that the world faces as of today. The current practice of pollution control, treatment and environmental protection can be considered very expensive activities where people consider it a burden for development (Dr El-Haggar, 2007.p, 17).

If sustainability is achieved, however, the world misconception that “environmental protection comes at the expense of economic development or vice versa” will be proven wrong. The author explains further that, Sustainable development

promotes economic growth given that this growth does not hamper the management of the environmental resources. The traditional approach to all forms of waste (clinical waste, agricultural waste, industrial and municipal solid waste, industrial and municipal liquid waste, etc.) can be considered disastrous worldwide because it is depleting the natural resources and may pollute the environment if it is not treated/disposed of properly. (Dr El-Haggar, 2007, p.17)

In addition, any propose solution should suit not only the developed countries but as well suit the developing countries by including the economical benefits, technological availability, environmental and social perspectives otherwise they will never be sustainable.

2.2.4 Zero pollution and 7rs rule

In 2004, according to the Global Waste Management Market Report (Research and Markets, 2004), the amount of municipal waste is about 1.82 billion tons with a 7% increase compared to 2003. However, the amount is estimated to rise by 31% in 2008 to reach nearly 2.5 billion tons. It was further emphasized that this enormous amount would cover the total continent of Australia at a thickness of 1 mm. Meanwhile, research has discovered that finding new sources of materials becoming costly and difficult. Concurrently, the cost of safe disposal of waste is escalating exponentially and even locating waste disposal sites are becoming more difficult. (Dr El-Haggar, 2007. P.12). According to El-Haggar, a new hierarchy of waste management to approach the full utilization of waste must be considered which starts from reduction at source, reuse, recycle and sustainable treatment for possible material recovery for conservation of natural resources. (Dr El-Haggar, 2007 p.12).

Many years ago, people's dream was to turn sand into gold; however, nowadays ideology is to turn waste and pollution into gold. This was a dream until the new hierarchy to approach zero pollution was developed at the American University in Cairo (El-Haggar, 2007…..2001c) and the 6Rs Golden Rule was initiated (El-Haggar, 2007……2003c). The author cited further, that the 7Rs Golden Rule

encompasses Regulation, Reducing, Reusing, Recycling, Recovering, Rethinking and Renovation as the basic tools for zero pollution (El-Haggar, 2004a). After critically examining, it was discovered that the rules provide a methodology approach to manipulate current activities in order to attain zero pollution and avoid landfill, incineration and/or traditional treatment that has been practices many years ago.

In addition, this approach is based on the concept of adapting the best practicable environmental option for individual waste streams and dealing with waste as a byproduct. (Dr El-Haggar, 2007, p.13).

After several applications of the theory and recorded successes, it is then concluded that 7Rs Golden Rule for zero pollution can be considered the Sustainable Waste Management Hierarchy for Zero Pollution and the Industrial Ecology Hierarchy for Zero Pollution. (El-Haggar, 2007, p.13).

For a clearer understanding, zero pollution can be defined as the pollution generated from any man made activity and should be within the allowable limits stated by the national or international environmental regulation or international environmental regulations. The concept of zero pollution is not new due to the new methodology developed by Professor Nemerow (1995) for the future of industrial complexes or parks to approach zero pollution. However, many nations have taken as a priority to work toward achieving zero pollution not only in industrial sectors but rather considering all other sectors.

From the above analysis, El-Haggar made it clear that traditional treatment, incineration and final disposal through landfilling processes for solid and liquid waste require a huge capital and might cause environmental problems if it is not managed and operated properly. If the treatment/disposal is not done properly, or the treatment/disposal facility is not well designed and constructed, the adverse impacts will be significant.

In conclusion, it is cited that ‘sustaining treatment has proven to be the most suitable solution and can be implemented to solve the problem of waste not only in developed countries, but also in developing countries compared with incineration

and/or landfill according to the 7Rs Golden Rule using the concept of cradle-to-cradle'. (El-Haggar, 2007 p.13)

2.2.5 Life cycle analysis and extended producer responsibility

According the author, USEPA has defined life cycle assessment/analysis (LCA) as a method to evaluate the environmental effects associated with any given industrial activity from the initial gathering of raw materials from the earth to the point at which all residuals are returned to the earth, a process also known as cradle-to-grave. Further explanation made know that the LCA result is not reliable as far as the evaluation is done for industrial activities that adopt a cradle-to-grave flow of materials. However, since the inception of the industrial revolution most manufacturing processes are based on a one-way, cradle-to-grave flow of materials; perhaps before, now they extracted raw materials, followed by processing, producing goods, selling, utilization by consumers and finally disposed. (El-Haggar, 2007, p. 13).

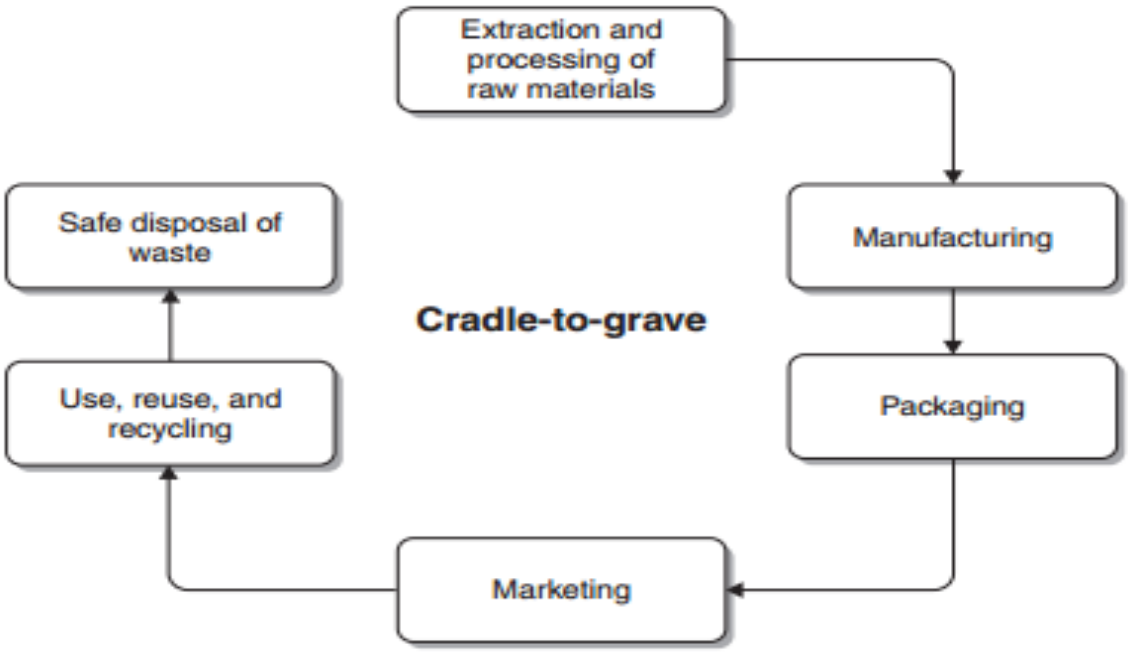

Figure 4: Traditional life cycle analysis (adopted from, El-Haggar, 2007,p14)

After several practical examinations, the cradle-to-grave flow of materials has proven capable to protect the environment but inefficient due to the depletion of natural resources.

Another author defines LCA as a tools that identifies the impacts of any given product on the environment throughout its entire life cycle or, in other words, from cradle-to-grave, i.e. from the extraction of raw materials; the processing of raw materials in order to fabricate a product; the transportation and distribution of the product to the consumer; the use of the product by the consumer; and finally the disposal of the product's materials after its use (TecEco Pty. Ltd., 2006,p.15) as shown in Figure 4 above. A further explanation point that identification and quantification of waste generated through the entire life cycle should not be the only main components of a life cycle analysis or assessment, but also the raw materials and energy requirements throughout the entire life cycle and their environmental impacts. (TecEco Pty. Ltd., 2006, p.15)

In addition, it is noted that many researchers have developed many different methods to obtain LCA and some has received approval for thoroughness and analytic consistency, and at the same time has been criticized due to too much data, time, and money required in a short supply.

3 RESEARCH ENVIRONMENT

In 1947 Dhaka became the provincial capital of the East Pakistan after partition of India, which later became the capital of an independent country known as Bangladesh. Dhaka City Corporation has divided and recreated as Dhaka south city corporation (DSCC) and Dhaka north city corporation (DNCC) December 2011. Dhaka south city corporation has been constituted by 56 Ward. Total area of south city corporation is about 47,21square km. On the other hand Dhaka north City Corporation has been constituted by 36 Ward. Dhaka north city corporation is situated northern part of Dhaka city. A total area of Dhaka north City Corporation is about 82,638 square km (DCC),(Personal interview, Harun A,2014)

Figure 5: Map is showing total area of Bangladesh. (Worldatlas, no date)

Dhaka city is located in central Bangladesh on the eastern bank of the Burigana River. Total population of Dhaka City Corporation DCC and DNCC is approximately around 10 million, of which there are about 6 million males and 4 million females respectively (DCC, Census 2011), Personal Interview, Harun A. Annual population growth rate 4.5 %. The city produces 6000 tons of waste per day. Wet seasons per day produce 6500 tons waste. Dry seasons per day produce 6000 tons of waste. During wet seasons waste generation rate increases 46 % (JICA, 2004). House-holds generate 4000 tons waste per day. 60 % to 70 % waste is organic. 80 % waste can be covered in values are complete. City Corporation has two land fill zones, one is situated in the north part of city known

as Amin bazaar and another one is situated in south east part of city known as Matuaile. 65 % of waste is disposed at the Matuail land fill zone and 35 % waste is disposed to the Amin bazaar land fill zone. (DCC. Personal Interview, Harun.A, 2014)

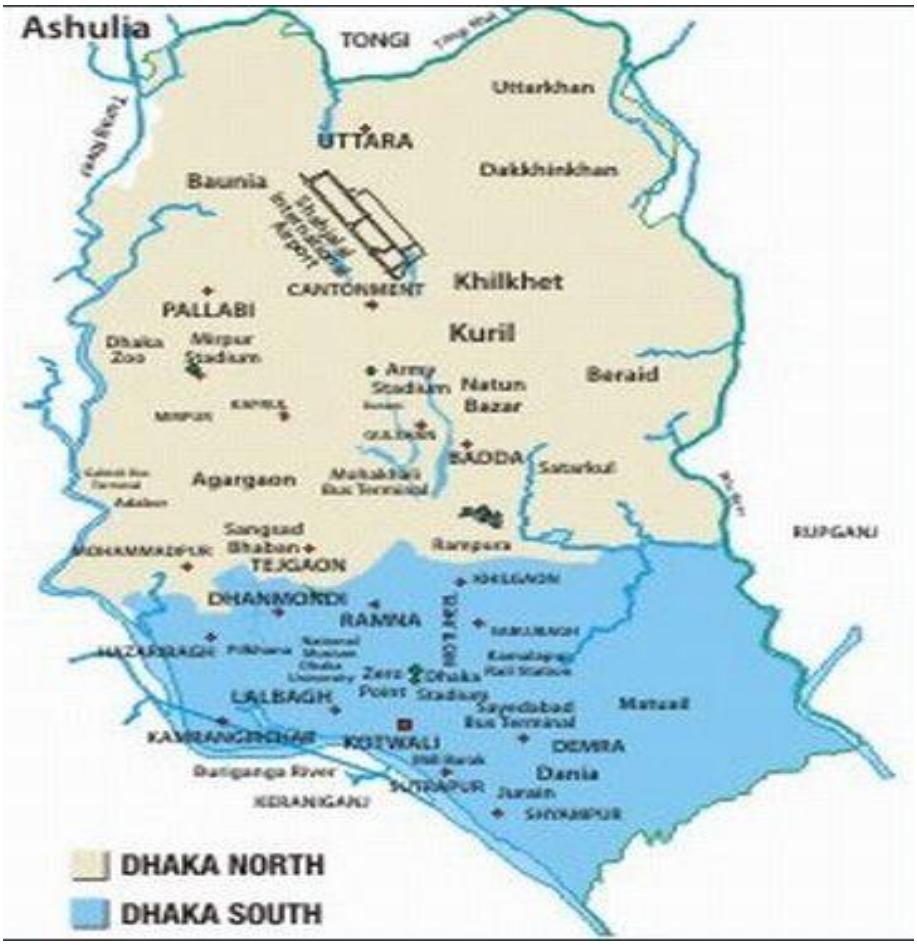

Figure 6: Map is showing total area of Dhaka north and Dhaka south City Corporation. (Media Bangladesh.net, no date)

Estimated range of waste generation per capita is between 0.45kg to 0.65 kg per day. Higher income individuals tend to generate more waste. Dhaka City Corporation has the ability to accumulate only 60 % -70 % of waste generated for waste disposal, the remaining waste gets scattered in open spaces, around the city in the streets and the rest of it gets dumped into the rivers, canals, water bodies and the low-lying areas prone to get affected by weather and geographic conditions. Another factor in consideration is that, 50 % of population is living below poverty-line do not have the know-how of waste disposal. Bangladesh

exports over 25000 tons of PET flakes (recycled PET bottles) every year. There are more than 3000 factories located across the country. Business is growing by 20 % every year. Nearly 3 million people are living in slums of the City Corporation, which contribute to the un-channeled waste due to unregulated consumerism. (Personal Interview, Harun A. 2014 (DCC)

4 CREATING WASTE MANAGEMENT IMPROVEMENTS IN DHAKA CITY

4.1 Current Waste management situation in Dhaka City, BANGLADESH

The city corporation of Dhaka is controlling waste management system in urban area. Formal sectors like municipality, authorized N.G.O, private and public companies, community policing are involved to clean up city area. A lot of cleaners are sweeping street and collecting wastes found in different places other than dustbins, road sides, and other spaces. City authority is using hand trolley for door to door and primary waste collection. Rickshaw van is used for house to house waste collection to municipal container. City administration is using Container carrier trucks, compactor trucks to collect accumulated wastes from bins at different location.

Figure 7: Door to Door waste collection. (DCC)

The mentioned picture shows the old and efficient way of waste collection system from door to door, but existing only in few areas of Dhaka City Corporation, as it requires a huge number of manpower, whereas, the second figure shows the collection of waste from garbage points. In some developed areas, the city corporation is utilizing compactor trucks for the waste collection system in Dhaka city.

Figure 8: Picture is showing house to house collection.(Archive.thedailystar.net July, 2010)

4.1.1 Informal sectors

Recycling of certain waste like newspapers, used containers, bottles, old clothes, shoes, which have some commercial value, are sold on the open market by the general public to scrap and metal dealers. Many scavengers are also involved in collection and selling of recyclable materials, bottles, waste papers, plastic bottles,

and some commercial wastes from the streets, waste bins, and dump sites to processing factories for reuse.

Figure 9: picture is showing scavengers incinerating wastes for collection of metal.

4.1.2 Problems

Due to bad policies of City authority, it has been unable to meet the demands to set up community bins and secondary garbage container in high density population areas. Ideally, the garbage container and the manpower for collection points should be directly proportional according to the population density, but the authority is concentrating more on already developed residential areas, which have more garbage points than needed. On the other hand, they have been reluctant to install similar garbage points and community bins in high density populations areas like the slums, which contributes to the largest portion of a variety of wastes that gets improperly managed.

A genuine workable strategy would be to calculate the population density in all the regions and the accessibility of garbage points, existing community bins, and distance between individual garbage points, which will give a central idea about the number of garbage points needed in every zone and their workability on a long-term. As a result of improperly managed and installed garbage points without the proper structural considerations, the citizens are forced to share bins and containers to dispose their garbage and sometimes beside the bins, even on the street. Another factor which the city authority is facing continuously is the lack of funds to set up the garbage points proportional to the rapidly growing city.

Figure 10: Picture is showing citizens are not using dust bin proper way. (Globalchallange.mit, no date)

A huge number of people in urban areas are poor and live in the slums. Individual waste generation by slum dwellers can be small but total waste generation is high as the number of slum dwellers is quite high in the city. Door to door waste collecting workers do not offer their services to slum areas, because slum dwellers are unable to pay the service charges. On the other hand, there are no community

waste bins in the slum areas and waste gets scattered in the open spaces for longtime, these wastes cause water pollution, air pollution and different kinds of dangerous diseases in slum areas. City Corporation does not pay attention to clean up slum areas as compared to the developed urban areas and the local governing bodies is reluctant to increase the operational costs and budget for the same.

Figure 11: plastic bag in slum area in Dhaka.

Plastic bags are huge obstacles for water passing systems in downtown slum areas. This picture is common in slum areas in Dhaka city. City slum dwellers are disposing plastic bags near the water passing drain; as a result plastic bags are blocking drainage system in downtown urban areas.

Hospitals and private clinics are generating huge amount of bio-hazardous wastes and they seldom meet the proper waste management system. Improper bio-hazardous wastes also get littered in the similar way as other domestic wastes. It includes used needles, syringes, blood and gauzes, bandages, discarded human organs, blood bags, others chemical wastes. These wastes are a major concern for cause of communicable diseases, for example, water borne hepatices B and C and diphtheria.

4.1.3 Transport system

Due to high expenditure local government are not able to provide sufficient number of waste disposal vehicles. Haphazard utilization of transportation increases the number of trips by the waste disposal units and in turn reduces the efficacy of the trip, thereby increasing the total cost of waste management.

Figure 12: Open truck being used to collect organic wastes in Dhaka city (Inthefray.org. no date)

Open trucks are not good environmentally, as they leave garbage and liquid waste on the streets while carrying those to dumping sites. So, instead of open truck, the city administration included environmentally friendly garbage trucks to reduce pollution and carbon emission in the Dhaka city corporation recently, but not enough in numbers.

Figure 13: Using compactor trucks to collect wastes from community dust bin and secondary container in Dhaka city. (DCC)

Since 2010 Dhaka City Corporation has been using environmentally friendly compactor trucks to develop waste collection system. The compactors will collect waste directly from secondary collectors in the city. There are about 3300 points, where secondary collectors dump household waste. (Personal interview, civil engineer Abdulla Harun, Dhaka City Corporation)

4.1.4 Sorting plastic bottles for export

In Bangladesh, over the past five years plastic bottles has created export commodity for the country. Discarded plastic bottles are providing much needed income for the national's poor. Poor people collect these discarded PET bottles from the streets and supply them to factories, where the sorting is done to make PET flakes. PET flakes are in huge demand in countries like Vietnam, China and Korea.

Figure 14: Separating plastic bottles for exporting.

4.1.5 Visit Waste Management Department DCC and Interview Result

A description of waste management department in Dhaka city Corporation (DCC): With the quantitative approach, a questionnaire-based interview was conducted to get some idea about the actual fact of waste management system and situation in Dhaka urban area. While conducting the interview, the interviewee (civil engineer, waste management department DSCC) described about the current scenario and plans in the pipeline. The purpose of the interview was to get a closer look at the steps being taken and the assessment whether the initiatives would improve the waste management system on the whole. DCC, Personal Interview, Harun. A

The governing bodies early in 2007 consorted with JICA (Japan International Cooperation Agency), an agency which specializes in waste management with multi-pronged approach with co-operation from the government and the community. The main focus of this project was strengthening of waste management in Dhaka city. JICA provided assistance to achieve waste

sustainability in Dhaka city and to improve waste management effectively. JICA worked with Dhaka City Corporation between the periods 2007 to 2011. The project provided financial, technical assistance and help in understanding the root cause in the ever-growing waste problems in a rapidly developing city. JICA organized workshops, special cleaning programs, community meetings, safety gears for cleaners, promoting healthy working among cleaners, working environment, and introduced collection system. According to the interview, JICA was able to help and definitely improve the standards of waste management in Dhaka but due to financial cutbacks and lack of social awareness among the communities, especially the slums, it was unable to continue further after 2011. During the tenure of JICA with Dhaka City Corporation, its main objective was to promote the idea of converting wastes in to resources; they promoted manufacturing of fertilizers from organic wastes such as fruits and vegetables, which were collected from the major markets and households in and around the city. The process flow started with the point to point collection system and subsequently supplied to industrial plants for sorting, pilling, maturing and composting. These composts would then undergo screening and bagging as ready products of commercial value. One ton of organic wastes produced quarter ton of ready compost. Marketing and sale of these items to fertilizer companies and the farmers and nurseries were channelized through JICA.

While conducting the interview, the interviewee gave the information about developing power from waste disposal plants, the projected time-frame for it and it is estimated at twenty years. According to the provided information, the government has adopted BOOT **(Build-Own-Operates-Transfer)** system; it is an initiative from the government for achieving its benchmark of developing power from waste disposal. Government has signed an agreement with one Italian firm to install the unit. Using wastes as a fuel the two plants are estimated to generate 100 MW of electricity. Initially plan is to use 1000 tons wastes to generate 10 mw of electricity and in the next three years it would generate 100 mw of electricity and some amount of fertilizer from two power plants by using around 5000 tons wastes per day. In plan, two types of power plants will be set up on the two land fill sites in the capital.

At Matuail an incineration plant is proposed, where electricity will be generated by using waste. At Amin Bazar anaerobic digestion plant will be set-up, where bio-gas produced from organic waste would be used. This initiative of turning waste into energy is first of its kind in Dhaka city which will add to the growing need of electricity in many areas in the city. It is believed to add 50MW of electricity from one power plant to the national power grid in the near future. This initiative is a definitive approach to waste management and power generation and thus will become a great way of waste sustainability. For the purpose of generating more power the proposal is to collect waste from neighboring municipalities like Gazipur and Savar besides Dhaka megacity.

Interview with the general public showed that the community was unhappy with government's narrow approach to achieve total cleanliness in the city. Their main concern was the under-powered municipality and their failure to provide a continuous support in managing wastes. They explained the need of action in the slum areas which is the source of the major part of littering in the city. Some people were concerned with the rising health hazards primarily spread of infectious diseases in the community. Children were at a higher risk of getting sick due to the pollution due to the wastes lying in the streets besides community parks and recreational places.

Dwellers in downtown slum areas were struggling to live with waste, because 20 % of the wastes were always lying in the streets. Citizens mentioned the lack of pro-active efforts from the local government in curbing this situation; they also shed some light on the municipal corporation's limitations and deficiencies with the NGOs functioning with DCC. (Personal Interview, Harun .A 2014)

4.2 Current waste management situation in Southern Ostrobothnia, Finland

Southern Ostrobothnia is a district in central Finland consisting of 18 of municipalities and Seinäjoki serves as the main centre. Total land area of southern Ostrobothnia is about 13 457 Sq Km and total population is about 194 000 (ref. regional council of southern Ostrobothnia). Total area of Seinäjoki municipality is

about 1432 square Km. Density of population is about 41.6 / Sq Km (2012) with about 60000 inhabitants.(Southern Ostrobothnia, 2014).

4.2.1 Methodology

Both quantitative and qualitative process followed for interviewing personnel in Lakeuden Etappi Oy. The research collected more meaningful and informative actual fact. All questions were about the activities of waste management system in Finland especially South Ostrobothnia.

4.2.2 Case Company

Lakeuden Etappi is a waste management company providing house hold and industrial services in the region of Southern Ostrobothnia. Lakeuden was founded in 1997 by covering 9 city corporations, which covers 100 km^2, inhabited by a population of about 129 300. Waste generated and collected per person is 263 kg per year from 64 000 houses. These wastes are collected from 12 points, 240 eco-points using 1 034 726 boxes, with a total waste collect per year of 120 000 tons, 88 % wastes is used for energy production and 12 % is discarded ecologically. Per year collect of 1 200 tons of organic wastes is used for bio gas plant. (Production of fertilizers from bio gas plant according to personal interview with Juha Hööpakka, 2014)

Lakeuden Etappi is regional developer of waste management solutions including waste handling, transport, providing information and advice related to waste management practices. It has its own land fill and bio gas plant. Lakeuden Etappi is the largest shareholder of Westenergy Oy. (Personal interview with Juha Hööpakka, 2014)

Figure 15: Figure-13: waste station.

Figure 16: Waste station.

4.2.3 Waste station and eco-points

Waste station is only for households and businesses. Waste station is located near every household and with a limit of two cubic meter of waste maximum that is allowed in every waste station. For larger quantities, wastes need to be transported to the Etappi's waste management center at Ilmajoki. (Personal interview, Juha hööpakka, 2014)

Eco-points are only near the households for recycling of paper, glass, and small quantities of metals. The operation of eco points and waste stations is funded by an annual charge per households.

Figure 17: Eco point.

4.2.4 Regional collection points

These kinds of collection point is only for owners of holiday homes in order to deliver their daily waste, household hazardous wastes and other form of waste that is not allowed in waste stations. Holiday homes owners pay fee seasonally and annually of the services provided by Etappi. (Personal interview Juha Höö̈pakka, 2014)

4.2.5 Waste transportation

Lakeuden Etappi provides transport, reuse and treatment of waste in its operating area. Waste transport covers wastes generated by residential buildings, holiday homes and public organizations, with the exception of hazardous waste. In addition, company receive hazardous wastes from households, agriculture and forest industries and divert it for appropriate treatment, waste from septic tanks and cesspools is also handled under municipal waste management.

Real time monitoring waste transport

Lakeuden Etappi is using TCS positioning system. The system can monitor waste transportation in real time, can verify operating location as well as ensure the customer's satisfactions. (Personal interview, Juha.Höökpakka, 2014)

Energy from sludge and bio waste

Lakeuden Etappi is one of the largest biogas plants in Finland. The plant processes sludge from municipal waste treatment plants, bio waste from households and businesses, and food and produce waste from supermarkets and restaurants. Food manufacturing industry also has the treatment service. Biogas and soil is produced from these plants. Soil conditioning granules are used as forest and field fertilizers, among other applications. Biogas is used as energy for the plant itself. Surplus biogas energy is used for generating electricity or as a transport fuel.

4.2.6 Waste-to-Energy Plant: Westenergy Oy

Westenergy Oy. Is waste to energy plant based in Vaasa, co-owned by five municipal waste treatment companies in Finland. It is a non profitable company and does not pay dividends to the share holders, in which, Etappi Oy is the main shareholder. The company operations are directed by cost efficiency and awareness, and they are optimized according to environmental regulations. One

third of the annual need of district heat is produced in the plant, and enough electricity is produced to cover the need 7000 households. About 100 truckloads

(One truckloads capacity approximately five tons) of waste are utilized in the Wastenergy waste-to-energy plant in a day. Electricity production capacity 13 MW in the plant. In The total efficiency ratio of the plant is 85 %. This plant is one of Europe's leading waste-to-energy plants. (Personal interview with Riina Härkönen, 2014).

4.3 Suggestion for waste management development in Dhaka City.

In recent times, many initiatives have been taken to reduce the waste problem and developing the waste management system in Dhaka, like community dustbins, collection points including transport and logistical support and separation zones, but a long-term recommended method of waste management system in Dhaka would comprise of:

Integrated collection: Collection of different kinds of waste should be implemented and monitored to maintain a garbage free society.

Selective segregation: After collection, a proper separation of wastes is required to ensure that, a quantifiable amount of recyclable material is obtained for supply to different industries which utilize recyclable raw materials. E. g. recycled plastic, metal, glass, paper.

Systematic combustion: Apart from recyclable wastes, there is a large quantity of waste, which will require disposal by combustion or burial. Combustion in garbage to energy method is the most ideal for generation of energy which can in turn help the community and industries respectively.

In order to achieve the vision in step-by-step manner, there is a need to set up more community dustbins, have to increase the manpower and transportation facilities for the effective waste collection system. Institutional strengthening is like role-specific training for authorized personnel to manage waste management

scientifically. Land-fill design for waste burial and set up for the new landfill areas should be located outside the city to avoid accidental spread and pollution of the urban areas. Need to educate general population about category-wise waste disposal system, in support of which, access to information should be available at all times. Improve public awareness by preparation of legislation and implementing specific laws, rules and regulations. Need more training and long term awareness programs to improve public motivation. Systematic advocacy in changing the public attitude like, dumping garbage, changing inappropriate habit, not avoiding waste fees by collectors. Build up campaigning program. Giving special importance to reduce and replace hazardous wastes that is harmful for environment and health. Individual and government interests like, establishing communication channel and setup of tribunal to hear grievances regarding garbage management and suggestions possibility, making decision on waste management issues effectively.

Dhaka City Corporation is using compactor truck for secondary collection. Local government has planned to buy more compactor truck. Nowadays most of the secondary container is on the street. In future local government is setting up secondary container beside the street instead of on the street. Government is also has taken attempt to reduce waste and increase recycling rate which will improve the quality of waste management system. Moreover, local government already has started education for consciousness and more publicity regarding waste reducing and recycling. Planning to reward scheme and incentive system contribute to the employee awareness and motivation on regarding waste reduction. Human waste with purifying plant (STP), the power generation plant using waste tannery, tannery solid waste and hoarding Plant and waste to refine Center Construction work in progress. Completion of the construction work in the next couple of years is expected (DCC). Already two environmentally friendly powers plants under construction and after succession government has planned to set up more power plants in Dhaka city from garbage. (DCC, personal Interview, Harun. A, 2014)

5 CONCLUSION

To summarize this study, it can be assumed that, as a developing country with high density in population, the average amount of waste generated per day is quite huge and there is an urgent need of managing this waste in the best possible ecological ways available, in order to have a pollution free environment for health and safety of the society. This paper reflects the current situation in Dhaka city's waste management system to be inadequate and incompetent due to very high population and the resultant waste generation because of high consumerism.

Although, the city corporation is servicing many areas for waste management, the total output of the services lacks the achievement needed for the waste sustainability. Compared to the Finnish waste management, Dhaka has yet to achieve the goal to manage waste with positive outcomes. Dhaka is in process to develop the most economic and environment friendly solution of waste to energy generation, but that alone cannot reach the benchmark standards of Finnish waste management systems. There are many other factors which have to be enforced to achieve the target.

In a rapidly developing society, ill-managed waste disposal system can become a major problem in the future leading to environmental crisis and economic burden. As such, the dire need is to implement a multi-pronged approach to curb the situation and turning the crisis into an economic reality. To begin with, it is essential to educate importance of waste management and practically implementing it in primary and secondary education institutions, the idea would be to educate the younger generations about the benefits so that they would follow the initialization in future. Simultaneously, community awareness should be promoted for healthy waste disposal regularly for the general public, so that every age-group is educated.

Secondly, introducing a transparent taxation system for the different types of waste generated by the community, based on social and financial strata, where subsidies for the population living below poverty can be proposed. A responsible society should have awareness of laws concerning the disposal of waste

generated by them which should be strictly monitored and regulated, imposing of fines and penalties in failure to compliance should be promoted. Stringent laws are part of a developed society in addition to the moral policing in regards to wastes.

Thirdly, government should have a systematic collection system for the most effective waste disposal. The densely populated areas should be given priority on the number of collections bins, secondary containers and dump trucks specialized in waste collection, allocate man power respectively, with effective wage system. Most often, the laborers working in this sector are underpaid, which is also a factor which impacts the system on a whole. Allocation of the required funds for this department should be the priority in a developing society.

Following the example of a developed country like Finland, where the companies like Etappi Oy and Westenergy Oy are managing waste and generating energy by utilizing the same waste, the Dhaka city corporation should put in resources and infrastructure in establishing energy plants which are primarily consuming huge amount of wastes to generate energy, which can then be used to benefit the community.

According to this paper, if an effective waste disposal system is achieved in the city of Dhaka, the government can use these methods in other parts of the country too. The corporation should not consider waste management as a commercially viable entity, instead it should observe it as non-profit organization servicing for the betterment of a clean and healthy society.

Since, this study is limited only to small area in Bangladesh, with minimal research, the results obtained as such are superficial, but in a definite direction. This topic would need a lot of research from a grass root level in order to get a detailed picture of the situation, based on which further suggestions and solutions can be recommended. Initially, a relatively smaller area can be researched with, to know the real implications so that the results thus obtained can be further used as a control point. The validity of this paper solely depends on the viewpoints of a handful number of people, so the real picture may be a little different. For the purpose of getting a better understanding, much more detail research is required

in the subject matter, although, this paper is reliable in terms of the general understanding of the situation of waste management system in Dhaka.

As per the data from Westenergy Oy., about hundred truckloads (Approximately 500 tons) of wastes are utilized in the waste-to-energy plant in a day and electricity production capacity is approximately 13 MW. According to the research and data collection, Dhaka City Corporation alone generates more than 6 000 tons of waste in a day, of which approximately 5 000 tons of wastes is collected for disposal by combustion. This is an ideal solution for the city authority to utilize these amounts of garbage as a fuel in the Garbage-to-energy plant, thus generating approximately around 130 MW of electricity for ready use.

The proposed Garbage-to-energy plant is being installed by the Italian firm and the government has negotiated the price of electricity at 8.75 BDT (about 8.8 euro cents) per kWh. At the electric production power of 130 MW this equals to income of 2. 7 million BDT (about 27 000 EUR) per day. This power plant would primarily develop the systematic collection of garbage for the plant with co-operation from government in order to deliver the electrical energy generated. This arrangement promises a huge potential for cheap energy, employment opportunities, money saving and pollution free environment. By adapting to this method, the garbage littering problem in Dhaka City should decline rapidly as it would be valued as fuel to produce electricity. This initiative has a huge advantage of preventing health risks involved with garbage pollution and have a safer environment by reducing the size of the landfill areas in and around the city.

With this study, it is understood that a good research process would need a very thorough know-how of the subject which is being researched. It requires the detail knowledge of the system processes which are being followed at the time. A good research depends on various key elements considering the topic in question. Knowing the research field alone is not enough for the research process and final evaluation. A more diversified foresight is needed to understand the implications of the research topic and the research problem involved, content analysis being a key element in the whole process. Identification of the research problem always deals with the ground realities of the topic; it cannot be assumed that a particular

problem exists without having enough data to prove it. A research problem can also present as an opportunity for further exploration, like the garbage problem presenting as a business opportunity.

The very concept of research process encompasses the possibility to provide solution for the current situation, where the problem has been discovered leading to practical suggestions for future assessment of the subject. Research methodology should include vast data from the area concerned, so that a statistical analysis can be done to understand the depth of the problem and the recommended solutions.

Future research in waste management system should comprise of every process individually, with the implications of it on the whole process cost-wise, efficacy-wise, environment safety-wise and consumer feasibility-wise. Moreover, every process can be differentiated and segregated in order to improve the efficacy of waste management, which in turn can also create employment options and entrepreneurship on small scale. Outsourcing many processes to different entities on competitive basis can help the whole system efficiently. Since every problem is an impending opportunity, the scope of future research in an area such as waste management is enormous. If every process is keenly studied, the prospect of entrepreneurship is considerable in size and definitely requires more individual research approach.

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