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Feasibility Analysis of Eco-Friendly Municipal Waste Management in Khulna City

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Abstract

The increasing population of Bangladesh leads to the growth of urban areas and slums which in turn, generating a huge volume of wastes. Thus disposal of waste has become a serious issue. Generation and characteristics of municipal waste in Khulna city, has analyzed along with the associated environmental impacts and existing municipal solid waste (MSW) practices. Main focus was given on feasibility analysis of municipal waste comparing with few alternative ideas. Evaluating those alternatives and find out the best possible way of energy extraction was the main purpose. Major portion of municipal solid waste of Khulna City in Bangladesh, is organic which are rapidly biodegradable and creating various environmental and health risk. At the same time the total daily household wastes generated in Khulna City areas is about 470 tons. Around 49 percent of total household wastes are managed. Because of unsatisfying solid waste management system in Khulna city, some common problems occurring such as diseases, fire hazards, odor nuisance atmospheric, water pollution and consequently economic losses. On the other hand, those wastes have a potential value of burnable biogas, generate electricity and organic bio-fertilizer. These potential factors convince us to compare few alternatives like Composting of organic waste, electricity generation waste burning and Biogas generation. In this context, to meet up the growing demand of bio-fertilizer, biogas and electricity, it is the best way to use renewable resources like municipal waste. It can help to minimize supply demand gap and create a modern well waste managed beautiful city as an example.

Keywords: *Municipal waste management, Eco-friendly, Bio-fertilizer, Electricity, Biogas.*

1. Introduction

Municipal solid waste (MSW) is considered as one of the most immediate and serious environmental problems confronting municipal authorities in developing countries like Bangladesh. The rapid growth of urbanization and uncontrolled urban sprawl, severely degrade environment, natural resources and consequently undetermined equitable and sustainable development. Now it is a major global concern which is increasing day by day. Now is the time to motivate our policy makers, politicians, environmentalists, economists and also the government about the proper utilization of urban waste to save our city dwellers. However, effective utilization of solid waste requires sound setting of human resources and technical support. Waste disposing is an important part of solid waste utilization system, which requires much attention to avoid environmental pollution. In context of Bangladesh, waste disposal and utilization is in a bad shape in urban areas since urban inhabitants generate huge quantity of municipal waste daily and in such areas population density is high. Only major cities have some sort of garbage disposal system. In the major cities of Bangladesh, per capita production of waste is 0.5 kg/day but only 0.2 kg of waste per capita is carried to the final disposal [5]. The rest is disposed locally. This view of the major cities of any country obviously exhibits the poor waste utilization situation of that country. An integral management approach for household municipal solid waste has to address the overall flow of material through various waste utilization activities, such as - collection, transport, separation, reuse, recycling, composting, treatment, and final disposal. Municipal solid waste recycling and composting has been found to be acceptable as a sustainable approach towards the municipal solid waste utilization in environmental, economic and social points of view [4]. If municipal solid wastes are not recycled, the land filling up will be very fast and as a result, dumping site could be exhausted and necessitate the construction of new one. It reduces environmental damage, enhances income generation activity, saves energy, conserves resources, and saves waste collection, transportation and disposal cost.

1.1. Objective of the study

- To find out the way to utilize the solid waste to generate compost/fertilizer, electricity, biogas and reuse of the society's resources
- Disclosing the existing Solid Waste Management practice in KCC

1.2. Methodology

This research is mainly descriptive in nature. This type of research has discussed about the present status of Municipal solid waste (MSW) system and its prospects in social, economic life as well as in environmental development. Secondary data has been used to prepare this research. At the same time, various interviewed information were used in this research preparation which are collected through informal talking with the expert and people directly or indirectly related to waste management and its use related activities. In this respect, it can be said that both primary and secondary data have been used in preparing this research. Following three alternative ways came into consideration for this research.

- Resource recovers from organic waste by Composting as Bio-fertilizer.
- Prospects of solid waste in electricity generation.
- Energy extract from waste as Biogas.

2. Literature review

Regarding the study entitled “Feasibility Analysis of Eco-Friendly Municipal Waste Management in Khulna City” there is not sufficient work in Bangladesh. Some research works conducted on some specific entitled topics. To grow concept, early ideas about the selected topic without the help of literature review is not possible. Various data, necessary materials can be collected from literature review. Sultana,T. (2006) stated the existing Municipal solid waste of Khulna City Corporation and determined the ecological footprint of waste generation of KCC area. She also recommended the way by which the ecological footprint of solid waste generation can be very effective tool for sustainable waste utilization in KCC area. Khulna Development Authority (KDA, 2013), this report stated that the daily collection efficiency of MSW (Municipal Solid Waste) is only 23 percent of the generated volume in KDA master plan area. The reason for low collection efficiency as stated in this report are insufficient funds to run the activities for collection and transportation of solid waste, insufficient number of equipment and carriers, insufficient number of road side rubbish bins, practice of improper use of bins and drains for waste disposal, insufficient maintenance staff and lack of public awareness on waste disposal system etc. Hoque,M.A. (2005), reported that the location of disposal (secondary) sites of KCC represent the unconsciousness about the environmental and public health hazards arising from disposing of waste in improper location. A suitable site must have environmental safety criteria's. Criteria for site selection include natural physical characteristics as well as socioeconomic, ecological, and land use factors. The Geographical Information System (GIS) can provide an opportunity to integrate field parameters with population and other relevant data or other associated feathers, which help in selection of suitable disposal sites. Salequzzaman (2005), stated that, Khulna city is reported to generate some 200-370 tons of wastes daily, per capita per day generation variously quoted lying between 0.22 kg and 0.75 kg. The city has a population of about 1.5 million. In Dhaka, per capita waste generation per day is 0.52 kg. Assuming the same value for Khulna, daily waste generation should be more than 750 tones which are sufficient for setting up a power plant about 3 MSW (Megawatt). To the knowledge of the consultant of this report, there has been no study on the quality assessment of Khulna city waste. Kashem (2007) stated in his research that, if the municipal solid waste which is generated in Khulna city is managed properly, it can be a potential resource. By using waste, biogas can be produced and the residue of biogas can be used as compost fertilizer and the produced biogas can be used as a means of producing electricity. In this way, potential resource can be recovered through waste utilization which is highlighted in his research.

3. Existing Municipal solid waste process in KCC

3.1. Generation of municipal solid waste

There is no reliable estimate about the amount of solid waste generated in the city. Generation of solid waste may vary with the income of people, household size, season of the year etc. It has been estimated that municipal solid waste generation in KCC is 470 ton per day [4]. On this basis the quantity of solid waste generated per capita/day is 0.5 kg [2]. The main source of waste is households [2]. In Khulna city total household are about 0.2 million [11]. Highest quantity of solid waste is generated in winter season and lowest in wet season. About 70 to 80 percent of the generated waste in city is organic in nature and rest 20 percent is inorganic in nature [2].

3.2. Primary collection and Secondary collection

KCC has a collection area of 45.65 sq. km. with total number of conservancy staff about 358 and 1200 dustbins [2]. There are minimum 10 to 20 dustbins in each ward [2]. Some of the dustbins are open at the top and some are covered. On realizing the present situation, it handed over some responsibilities of taking solid wastes from house to house collection of some wards to the several NGO (mainly Prodipan) [8]. The secondary collection means, after primary collection, the primary collection blocks are served by transport points and taken to the final disposal point by a large truck. KCC estimates about 470 ton of wastes are generated daily in the city area and only 120 to 125 ton are collected by it workers and the remaining are dumped irregularly [4]. KCC has 65 secondary disposal sites and some disposal sites are placed with demountable container, from where workers collect wastes with recommended KCC vehicles to the final disposal site in a regulated timetable. It has regular 22 to 25 trips to the final disposal site daily [2]. Rajbandh is the main dumping station of the KCC [2].

3.3. Collection system of private organization

Door to door collection systems are adopted for solid waste collection from generating sources and then dispose major portion of to the nearest secondary disposal system (SDS) [11]. NGOs and Community Based Organizations (CBOs) collect waste from approximately 28 to 30 thousands households [7]. Among the total generated waste of 420 - 470 tons per day, only 240 to 260 tons are transferred and disposed from SDS to Ultimate Disposal Site (UDS) by the city authority. Waste collections from sources and disposed in SDS by NGOs and CBOs are 40 to 50 tons per day, which is 9 % to 12% of the total generated solid waste [11]. The remaining solid wastes are collected from sources by city authority, private organization and drop to secondary points by householders and remain unmanaged [3]. In this collection process normally 71 vans are working daily without any day-off. Each van provides double trip per day having an approximately capacity of 270 kg/van/trip [7].

4. Feasible Eco-friendly municipal waste management systems

4.1. Resource recovers from organic solid waste as Bio-fertilizer (Composting)

Composting is the controlled bio-degradation of organic matter, usually under amebic conditions, by which a material is transformed into compost. Compost is the stable aid product derived from biological degradation of organic material, which can vary from dead leaves and roots to kitchen waste and vegetable remains under controlled conditions. If properly decomposed, compost is free from odor and pathogen free brown mixture which can be used as soil conditioner. Compost increases the efficiency of plant nutrient uptake, water-holding capacity of soil and soil aeration. Compost helps to increase better nutrient distribution and retention by the soil. Factors in favor of composting as a resource recovery option for Khulna city are 78 % of total generated solid waste in Khulna. Moisture content of 50% to 60% is optimum for aerobic composting. The typical moisture content of Khulna city is 55%, which is within the acceptable range for composting. Table 1 shows present composting plants in Khulna city.

Table 1: Details of composting plant in KCC area [1]

Name of the NGOs	No. of Plant	Plant size (m2)	Land ownership	Maturation period (days)	Unit price (Tk/kg)	Manpower involved	Special provision
PRISM Bangladesh	04	899	Self	50	6	10	Waste water treatment project
		360	Self	50			
		360	Self	50			
		540	Self	50			
PRODIPAN	01	733	KCC	60		6	
RUSTIC	01	614	Self	50		5	

4.2. Composting strategy for Khulna city

It has shown that in developing countries, large centralized and highly mechanized composting plants have often failed to reach their target and had to be abandoned due to high operational, transport and maintenance costs [5]. In many cases, small-scale decentralized communal composting plants may be considered as a suitable option for treating municipal solid waste as they reduce transport costs, make use of low-cost technologies, based mainly on manual labor and minimize problems and difficulties encountered with backyard composting.

4.3. Land, number of plants, manpower and investment requirements for composting

Table 2 shows land required for composting as well as number of plant and manpower required for this purpose. In total 13.24 bighas of land is required for composting of all the organic waste generated in Khulna city. For composting, fresh organic solid waste is necessary as raw material which can be collected by introducing house-to-house collection of solid waste. 300 workers are required for operating decentralized compost plants effectively [9]. These workers should have basic knowledge of different steps involved in composting process such as pile formation, temperature and moisture control.

Table 2: Land, manpower and estimated cost involvement for installation of different capacity of decentralized composting plant in Khulna

Items	Capacity of composting plant		
	3 ton/day	10 ton/day	20 ton /day
Land require/ plant (katha)	5	16	33
Fixed cost/plant(Tk)	5,16,640	17,22,133	34,44,266
Operating cost/plant(Tk)	344,600	1,148,666	22,97,333
Total Labors/plant	6	20	40
Compost produced (daily)	750kg	2500kg	5000kg
Expected revenue from sale of compost(Tk)	600,000	2000,000	4,000,000
Number of plants required	50	15	7

4.4. Landfill gas to power generation

It is a traditional method to process solid waste. This system has been used to generate power in Australia, USA and Europe, though the amount of gas less than that produced with other technologies. This technology is suitable for Khulna city solid wastes because of high moisture content and low energy content solid wastes at scale of 470 tons per day. Under this method anaerobic digester for bio gas generation has to be used. Anaerobic digester is a leak-proof digester to produce gas for subsequent use. Figure 1 shows the basic procedure to produce electricity from municipal solid waste.

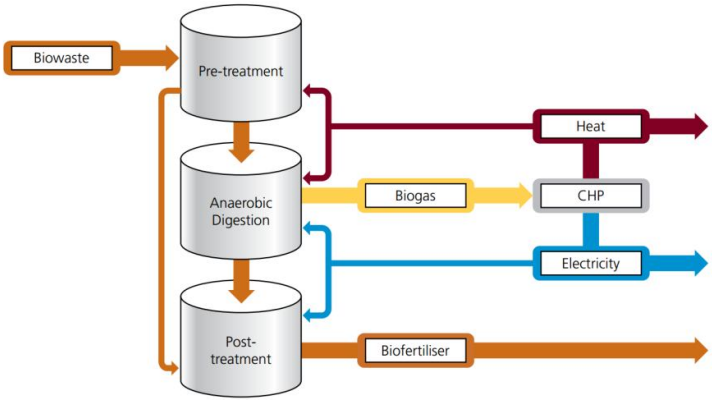

Fig. 1: Process of power generation activities

After digestion, scavengers with necessary safety measures will be employed to separate the remaining recyclable materials. Biogas does not have any leachate problem. It leaves a residue for use as soil conditioner and with biogas burning is uniform. So, there is no need of additional supply of gas from other source.

4.5. Cost consideration

Though electricity can be produced from solid waste but its production cost is higher than usual production of electricity. As we produce electricity from solid waste, with the subsidy of government, we can sell per unit of electricity at taka 6 where Power Development Board sell electricity at taka 4. If we are producing electricity from solid waste, we are able to supply it to different organization during load shading period. These organizations are mainly depending on generator base electricity supply during load shading. So, they are very much eager to buy this electricity at price six which is lower than generator based electricity supply.

4.6. Energy extract from solid waste as Biogas

Different organizations both government and non-government are involved in disseminating the biogas technology throughout the country. Total number of biogas plants in the country is about 25000 [12]. So far Bangladesh Council for Scientific and Industrial Research has installed about 22000 biogas plants in the country. Besides, Local Government Engineering Department (LGED) has installed about 1167, Bangladesh Rural Advancement Committee has installed about 1200, Grameen Shakti (GS) has installed 500 and Department of Environment has installed about 260 biogas plants in the country [7]. However, the number of biogas plants in the poultry sector is not significant.

4.7. Cost-benefit analysis for biogas plant

MSW based anaerobic digestion plant may be small scale or large scale. For small scale, it may set up for family and for large scale, it may set up beside a dumping site where produced gas can be converted into electricity and this electricity can be supplied for city dwellers. Anaerobic digester's cost varies widely. Table 3 shows fixed cost and operational cost of a biogas plant. At the same time, Table 4 shows earning and cost-benefit analysis of it.

Table 3: (a) Fixed cost involved for a biogas; (b) Plant Operational cost (per year) for biogas plant

Item (a)	TK.
Construction of cost of 3 m^3 biogas plant	30,000
Construction cost of sorting platform with shed	45,000
Construction cost of office and toilet facility	50,000
Purchase of 3 rickshaw van of TK.15000 each	45,000
Water and electricity connection	50,000
Equipment's for composting, dress for workers	50,000
Total fixes cost	2,70,000

Item (b)	TK.
Salary of six worker and Tk. 2000 per month	1,44,000
Salary of two van driver and Tk. 1500 per month	36,000
Salary of four waste collectors and Tk. 800 per month	38,400
Salary of plant manager and Tk. 6000 per month	72,000
Electricity and water bill	5,000
Raw materials for biogas	12,000
Depreciation cost	27,000
Total operational cost	3,34,400

Table 4: (a) Earning (per year) from biogas plant; (b) Cost-benefit analysis for biogas plant

Item (a)	TK.
Sale of biogas from plant 18 m3 /day and TK 5/ m^3	32,850
Sale of bioelectricity from biogas 27 kwh/day and TK 5/ kwh	49,275
Sale of compost 100 kg from processing 400 kg of waste per day and TK 6/kg	2,19,000
Monthly charge for house to house waste collection service rendered and TK 20/ household from 500 households	1,20,000
Total Earning	4,21,125

Item (b)	TK.
Total fixed cost for first year	2,70,000
Total operational cost for the second and subsequent years	3,34,400
Total earning per year	4,21,125
Average cost /benefit ratio considering 30 years project	1.23
Production cost of 1 m^3 biogas (considering 30 years project)	3.5
Selling price of 1 m^3 of biogas	5
Selling price of 1 kwh electricity	5
Selling price of 1 kg fertilizer	6

4.8. Comparison of unit cost

The production cost of 1 m^3 of biogas from cow dung based biogas plant is 8.25TK.
The production cost of I m^3 of biogas from MSW based biogas plant is 3.5TK.

5. Findings

Findings are very essential part of a research. In findings, not only the prospective things of the research are highlighted but also the problems that a researcher faces during conducting the research. Despite facing some problem to collect data, some interesting findings came into light.

- All of three alternative ways are suitable for MWM in Khulna but combination of two or three of them will be more efficient energy extraction process.
- Municipal solid waste contains various compositions with specific merit of each. So solid waste need to be separated with its merit and use as specific energy extraction process.
- All three processes are viable in Khulna city for specific kind of solid waste.
- Production of compost, biogas and electricity helps to protect the open decomposition of organic waste that contributes to air pollution.

- Production of electricity reduces greenhouse gas emissions.
- Small scale community based compost plants can save 15 acres of landfill area per year.
- More than 40 tons of organic compost can be produced in Khulna city if the total generated organic waste is recycled every day. The decentralized community based composting plants can generate employment for the poor, especially the women, and offers new prospects for small entrepreneurs to take part in recycling business.
- By using 415480 kg of solid waste, 1445.2 m^3/day biogas can be produced easily.
- Using this generated gas can produce 1, 93,408.55 MJ/day energy.
- On the other hand, there are various types of generator that are used to convert this biogas into electricity (around 22,126.11 kWh).

6. Conclusion

Existing solid waste generation is a burden for its dumping due to lack of dumping sites of Khulna city. But Khulna City Corporation's waste is increasing with the increasing of population. Thus it is crucial issue for Khulna City Corporation (KCC) authority and this is the time for making strategic plan on how growing burden of municipal solid waste is to manage significantly with innovating technologies. On the other hand, KCC along with the whole country is passing absolutely shortage of electricity. In addition, south-western Khulna region has no gas supply for cooking purpose where almost rest of the country is enjoying gas facilities. In this situation, MSW has a great significance to produce extra gas as well as ecologically sustainable organic bio-fertilizer from the biodegradable solid waste by using the anaerobic digestion process. This amount of electricity, bio-fertilizer and biogas can contribute in the economy by saving the extra money and minimize supply demand gap. Beside this, by processing the large amount of municipal solid waste, it is possible to maintain environment in a better way. Thus the environment will get rid of from the hazardous impact of waste and produced gas, electricity and bio-fertilizer will met the daily energy demand of Khulna city dwellers.

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