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Municipal Solid Waste Management: Scopes, Challenges of Sustainability and Treatments in Rajshahi City, Bangladesh

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ABSTRACT

The world is facing an enormous waste management problem nowadays. Municipal solid waste is one kind of a severe environmental threat and amiable concern globally. Adverse environmental outcomes from undeserving waste management can be frequently noticed in developing countries like Bangladesh. Turning MSW (Municipal Solid Waste) into energy would save more valuable fuels and enhance the environment by altering the quantity of waste to be disposed of and preserve energy and natural resources. The paper focuses on the waste to electricity production from the municipal solid wastes in the Rajshahi city of Bangladesh. A vast amount of solid waste is discarded in Rajshahi city, affecting habitat contamination and health endanger. The report suggests that MSW incineration can be a possible WTE (Waste to Energy) green power generation plan in RCC (Rajshahi City Corporation). Incineration is a useful technique for reducing the quantity and weight of solid waste, though it's a greenhouse gas supply. In modern incineration plants, the waste is burned within an adequately designed chamber below terribly rigorously controlled conditions. To prevent the release of organic compounds, air/fuel blending and temperature must be carefully regulated and "quench" areas in the oven avoided. This paper proposes incineration heat generated at a combined heat and power station and ash for construction and deposit. The pretreated MSW for fuel is expected to have a typical heating value of 1450 kcal/kg during a WTE plant.

Keywords: Waste technologies, incineration, solid waste management, impact; Bangladesh.

1. Introduction

MSW generations are considered one of the most significant environmental issues of contemporary development cities. It is one of the most notable municipal ecological concerns. The MSW administration is facing significant challenges in a developing country as Bangladesh [1]. Waste management is a big necessity for the municipality. Solid waste management turns more imposing when the municipality consists of different classes of people [2]. Municipalities in the cities are mostly responsible for MSWM (Municipal Solid Waste Management). To make a significant and reliable SWMS (Solid Waste Management System) possible is too tricky for the citizens [3]. Incompetent solid waste management and disposal is a direct cause of environmental degradation in most developed world cities [4].

Developing countries' municipal companies are no longer able to manage the waste, and essential waste is not processed, collected, or disposed of correctly in the right places for final disposal due to a lack of passion, knowledge, integrity, and resources [5]. A large part of the population does not benefit from waste collection, and only a limited number of wastes produced are collected by a door-to-door system announced at the end of the 90s [6]. The people living in the RCC produce wastes of 420 tons/day [7]. Thermal treatment can reduce waste volume by up to 85%, which may, at the same time, lead to two problems: solid waste disposal and energy reproduction [8]. The city of Rajshahi produces about 360 tons/day of solid waste. The generation rises over the summer to 400 tons/day [9]. Rajshahi is an indigent city firm compared to another, and the management of MSW is one of the concerned shipments in that city [9]. With convenient planning for the use of MSW the once-probably 9% of renewable production energy total is set in the “Master Energy Systems Plan” by the Government of Bangladesh (GOB) and could make cities green and clean [10].

The paper illustrates the present MSW scenario in RCC area; waste generation, collection, transportation, and health and environmental impacts. Lastly, some waste management systems are urgently required to establish critical options for leading a healthy community within the RCC.

2. MSW management approach in RCC

The management of waste is extremely essential to guarantee a safe environment in big cities such as Rajshahi. Wastes are arranged in two different sites. They are primary disposal sites and secondary disposal sites (SDSs). In Bangladesh, the SDSs are generally open space or street-side areas. Less than 50% of the wards oversee to gather waste by ‘door-to-door waste collection,' but it is thought of ensuring the facility for

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every ward in the short term[6]. The 'Nawdapara' is a dumping place with a depth of 3.4 meters and a surface area of 15.95 hectares [6]. Around 350 tons/day of waste is moved to the RCC's final disposal site [7]. Fig.1 describes the proposed MSW management approach in RCC. Waste picker and door-to-door collector collects wastes from disposal site and municipal collection point. Then the wastes are recycled in recyclables shop which goes to the recycling industry. Next, the waste from households goes to door-to-door recyclables, which also transfers into the recycling industry. Thus, the management system is analyzed.

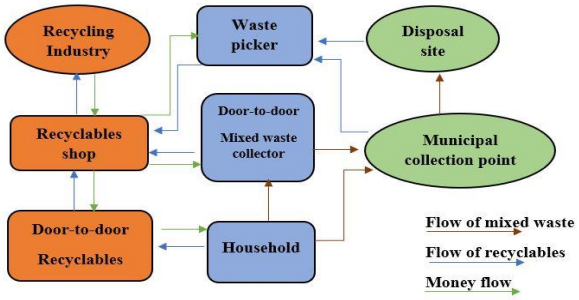

Fig.1 The proposed MSW management approach in RCC

3. Field research on MSW generation in RCC

Waste is a substance of no further use and requires storage and disposal on-site or off-site. MSW consists mainly of organic matter, paper, plastic, leather & rubber, glass, textile & wood, and others produced from residential areas, administrative areas, industrial areas. Fig.2 describes the monthly waste generation (tons/day) in RCC. From April to July, maximum waste generation was observed, which is 425 tons/day, and the minimum waste generation is observed from October to February, which is 385 tons/day.

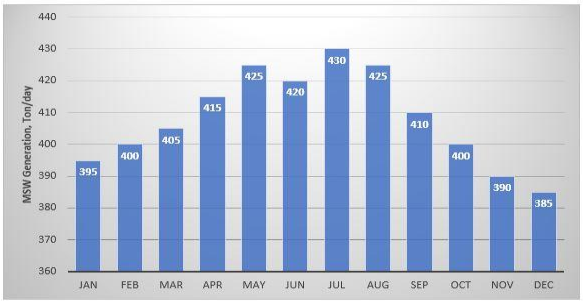

Fig.2 Monthly waste generation (tons/day) in RCC

4. MSW generation, composition, and transportation

Municipal solid waste generation rate in Rajshahi city is inked to population surplus, economic growth, and rapid development. In Table 1, it is shown that trade, like consumer waste, is maximum. This is due to the ongoing urbanization and growth of employment. Household waste is second due to lack of intensity in collecting waste from the door-to-door through the number of waste generation is less. Wastes found in lanes at a high amount are common everywhere in this country since the number of populations is high and improper waste management. Food and natural wastes are higher than clinic waste because of common people's unconsciousness, e.g., people are less interested in using dustbins [6, 9].

Table 1 Waste generation in Rajshahi City Corporation [9]

Sources	MSW generation (kg/day/capita)	MSW from various sources (%)/day
Household waste	0.403	40.3
Sweeping lane	0.11	11
Trade like consumer waste	0.44	44
Food and natural waste	0.005	0.50
Waste from clinic	0.002	0.20
Others	0.04	4.0
Total	**Waste generated 1 kg per day**	**100%**

The physical composition of waste varies over the years with the country's economic progress, increased residence, population density, change in food habits, education, social norms, and globalization effect [11]. This physical composition (Table 2) also can be subdivided by organic compounds and inorganic compounds. Organic compounds add food and vegetable residue, wood waste, textiles, paper, plastic, and rubber. Besides, inorganic compounds add tiles, ash glass, tins, and other inert chemicals [10]. The percentage of food waste is also high in mean physical composition [6]. Data of various compositions are shown in Table 2 below from a recent publication.

Furthermore, Table 2 also represents that foods and vegetables contribute approximately more than two-thirds of total waste generation. This is because of people's over-reliance on them and the unawareness during consumption, preservation, and processing. However, glass and ceramic contribute lesser than all other composition in total waste generation in this city.

Table 2 MSW physical composition with the percentage in Rajshahi City Corporation[12]

MSW composition	Total generation (ton/day)	Wet weight %
Vegetables and foods	298.92	71.1
Paper products	37.04	8.9
Plastic	12.26	4.0
Textile residue and woods	8.48	1.9
Rubber and leather	4.95	1.1
Metal and other metal residues	5.04	1.1
Ceramics and glass	5.04	1.1
Concrete and stone	7.56	2.9
Others	35.70	1.3
Total	**420.00**	

A significant part of a sound solid waste management system is the chemical composition (Table 3). The disposal and energy improvement process depend on the data of the chemical composition of solid dissipation. The following table below exhibits the percentage of carbon and oxygen is very high than other elements. Improved components are carbon, oxygen, and hydrogen. This is due to organic wastes, which are hydrocarbons are prior to inorganic wastes. [6].

Table 3 Chemical composition of MSW in Rajshahi City Corporation[6]

Components	Weight (%)
Carbon	50.24
Nitrogen	1.86
Hydrogen	7.51
Sulfur	0.02
Oxygen	40.16
Others	0.21

The collection of MSW is to store and move the waste to the final disposal. An effective transport system can minimize emissions. In the Rajshahi City Corporation, there are several vehicles used to move MSW. The number of vehicles is described here- (a)No of ward rickshaws, 180; (b)No of central rickshaws, 48; (c)No of ward wheelbarrows, 90; (d)No central wheelbarrows, 60; (e)No of trucks, 12.

The percentage number of vehicles that are used to collect and transport MSW is visualized in Fig. 3. However, the number of trucks should be increased in case of proper utilization of the transportation system. Trucks are used to collect waste from different areas of cities and transport it to landfills, incinerators, and other stations at a large amount of scale. It can save both time and manpower, whereas a large number of small vehicles are less efficient at some routes [13, 14].

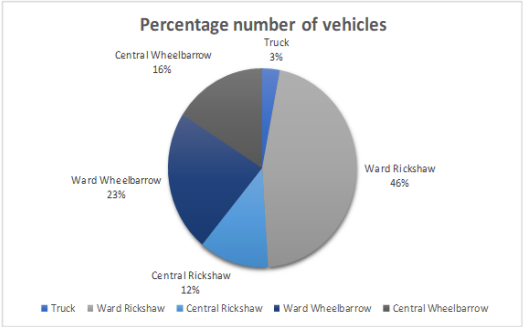

Fig.3 Percentage number of vehicles used in transporting MSW [14]

5. MSW collection and storage

Most of the population doesn't get any access to MSW assortment services in Rajshahi City Corporation. The collection of MSW is challenging because, in every home, factory, industry, and every street or open space, various forms of waste occur. RCC has 30 wards, but RCC is working to offer this service to all wards eventually, just a fraction of the waste currently collected by the door-to-door collection system. Besides, 45-55% of waste is not fully treated, processed, or disposed of at sites allocated for final disposal because there is a lack of incentive, consciousness, and hope [15]. At the primary stage, all wastes are collected between 5 am to 1 pm, then the reservation department is liable for collecting the secondary waste from its bin to its ultimate disposal place. There is a dumping site with an area of 3.5 feet in 15.98 acres in 'City bypass' and 35 secondary collection points [5]. There are several rickshaw vans, hand trollies, dustbins, and trucks to collect them and also for temporary storage. There are also 34 permanent workers, 594 daily payment based central workers, and 777 daily payment-based ward workers involved in managing solid waste. (Source: Rajshahi conservancy division).

6. MSW Disposal

Temporary and final disposal sites are open, unregulated, and transiently controlled within Rajshahi City Corporation. Collected wastes are temporarily stored in roadside or dustbins and finally disposed of in a free place named "Nawdapara," which is 3 kilometers away from the City Corporation area [5]. This disposal site is not managed insufficiently and does not ensure the basic principles of salutary landfills. Waste spreads all around the disposal site, and it creates a very unpleasant odor. Also, dry and low weight wastes fly on and pollute the environment. There are 3 hospitals, 47 clinics, and 22 diagnostic centers in Rajshahi City Corporation [6]. The ordinary wastes from those places are the gauge, bandage, medicine packet, food waste, sanitary pad, saline bag, placenta, papers, syringe, cotton, etc. Wastes with a severe and neglectable public

health effect are immediately buried under the ground in the Rajshahi Medical College Hospital incinerator and not burnable [6]. But overall disposal systems of Rajshahi City Corporation are poorly planned and unhygienic. They need to follow proper steps to decrease environmental pollution as well as an unpleasant odor. There are two sorts of wastes, one of them is biodegradable, and the other is non-biodegradable. Specialists should utilize the non-biodegradable waste for recycling or landfill and the biodegradable for energy generation. Most of the waste power plants will solve the Rajshahi City Corporation's disposal problem.

7. Onsite Disposal

7.1 Incineration

It is an efficient process to reduce the volume of waste. It can be concluded to off-site disposal. This process should be done far away from society. A large number of wastes can be reduced by burning, and also, it doesn't take to space as the landfill process take. Waste should be within pits and covered with soil once incinerated [9, 11]. In this process, waste can be reused or converted into new materials by further recycling [6]. Sometimes it is challenging to maintain incineration waste [11]. This is because some uncertain gas is produced, which can be harmful to our health. The air emissions from waste incinerators have been identified as a cause of cancer. Air emission occurs due to heavy metals, volatile components, dioxins, and other organic components, the subfamily of solid waste. Those incinerated components can be driven into different places and sustain for decades in the environment without being perished and mixed with soil, water, and foods. Ash is another product of incineration. The toxins in the ash finally leach into soil and water from ash deposits [16].

Some best practices can lead to substantial reductions in the formation, emission, and exposure in case of waste incineration. Moreover, the Waste reduction can considerably lessen demands for incineration and provide other significant benefits, e.g., more excellent environmental protection, enhanced occupational safety, health, etc. Precise design and management of incinerators can be achieved at desired temperatures, pressure, working time, and other conditions necessary to destroy pathogens from hospitals, lessen emissions, reduce clinker formation and slagging of the deposits and finally minimize fuel wastage. The placement of an incinerator can prominently affect the diffraction of the flame from the chimney, which in turn affects ambient situations. Desired practices siting has the target of finding a placement for the incinerator that lessens possible risks to people's health and the environment [17].

7.2 Landfill

A significant area for processing or recycling waste. This method's main objective is to keep this waste away from surrounding factors such as groundwater [6]. Garbage is deposited into the landfill area [11]. A site survey can be efficient for digging. After making the leachate draining slab, waste is ready to be poured. After these procedures, the landfill area should be covered up with soil [6].

7.3 Composting

It is another disposal process of solid waste. It can be on-site or off-site, depends on the number of waste materials [11]. Many people have their garden, land where vegetables are grown, they can use those waste materials by turning them into compost [6, 11]. Composting is the regulated dissipation of organic materials through biological methods [6]. Composting engages a combination of vegetable surplus, animal substances, soil, and water to produce humus [6, 11]. This process helps prepare the waste to use and collaborate in the growing system [11, 18].

7.4 Recycling

One part of solid waste can be recycled without passing through them any other disposal process. It's an easy process. In waste materials, some waste can be automatically recycled. Some waste materials like plastic bags, jars, tins, and glasses got a little scratch or fragile condition which can be easily repaired. In developing countries, it is becoming a vital disposal choice [11, 19].

8. Offsite Disposal

8.1 Communal Pit Disposal

Communal pit disposal is one of the only ways to dispose of a huge number of solid wastes of a community. A pit where people dispose of their waste. The capacity of this will depend on the number of people who live in that society. For children's safety, barrier ought to be utilized, conjointly concerning our health, it can be placed a little far from society. Additionally, the pit should be covered up [11].

8.2 Family Pit Disposal

Family pit disposal is the simple and easiest way to dispose of solid waste for a single-family. Selecting a space or land in their area and make a pit (not too deep) and dispose of their waste regularly on that pit and those waste should cover mixed up with soil. This process will be a vital factor for families where domestic waste and organic waste are produced more [11].

8.3 Communal Bin

For smoothly removing and conveying disposal, and also gathering waste in one exact place. Communal bins are perfect for use. Wastes are not dispersed everywhere. Also, it makes further procedures easy, like collecting waste in an exact place without any trouble. This bin is not so big and even not so small. A medium-size drum can be used. The drum's bottom level should permeate to admit liquid to flow and prohibited for other phases of waste. Generally, the drum size is fixed for a fixed number of people [10, 11].

8.4 Family Bin

Small size bins can set up in any corner of the house. It helps to store all waste in a definite place. If people take responsibility for their garbage, then the pressure of communal bins is reduced. The problem is that this bin is scarcely used [6, 11].

9. Impacts on environment and health

Incomplete waste management is mostly responsible for environmental pollution. It advances the spreading of diseases as well as contaminates water bodies [9]. Moreover, a primary environmental involvement is gas release by disintegrating garbage. Methane gas, which is an outgrowth of bacteria's anaerobic process, contributes to the upgrade greenhouse gas effect and climate change [20]. Undisciplined hazardous wastes dumped into the drainage/sewage system lead to a severe impact on health.

On the other hand, the child mortality problem is a necessary concern—the increment within the hazard of a birth deformity happening in babies [9]. Improper waste management causes low childbirth weight along with increases sensual disease [20].

10. MSW as the energy potential

Solid municipal waste can be used for energy transformation. The heat value of solid waste may be used to produce energy in the form of heat or electricity. With energy recovery from waste, WTE can be the solution to the question of MSW management and can provide the residents with a better living atmosphere. Food or vegetable waste with a humidity level above 65% are over 75% of the waste [2]. RCC MSW's calorific value is calculated to be 15.41 MJ / kg, which is very good for electricity generation [2]. MSW can also be used in RCC as an electric energy source [2].

Using the Updated Dulong equation, the MSW's energy content is calculated, and the accessible power derived from this MSW energy is calculated [2].

Updated Dulong's Equation:

$$Heat\ energy = 337C + 1428\left(H - \frac{O}{8}\right) + 95\ KJ/kg \quad (1)$$

$$E_s = 0.7 \times E_H \quad (2)$$

$$11395\ E_p = E_s \quad (3)$$

$$S_A = 0.06 \times E_P \quad (4)$$

$$U_H = 0.05 \times E_P \quad (5)$$

$$E_{NP} = E_P - (S_A + U_H) \quad (6)$$

Where, C= Carbon (%)
H=Hydrogen (%)
O=Oxygen (%)
S=Sulphur (%)
E_S = Steam energy available
E_H = Heat energy available
E_p= Electric Power Generation
S_A = Station service allowance
U_H = Uncounted heat loss
E_{NP} = Net electric power generation

The overall MSW generation in Rajshahi City Corporation is 400 tons/day, an estimated 4.482 MWh / day of net electricity [2].

11. Preferred Technology

The Mass Burn Incinerator is an energy technology primitive waste. Composite waste is processed into more usable residues by incineration, and the key advantage of generous waste weight (up to 70%) and volume reduction (up to 85%). In the meantime, MSW is combusted at a higher temperature, with air also provided to provide a balanced and normal molecular shape for the entire combustion of components. In addition, WTE will reduce MSW's transport to remote sites and combined emissions and fuel consumption [8]. A new waste management framework is proposed for RCC after tracking the current system shown in fig.4.

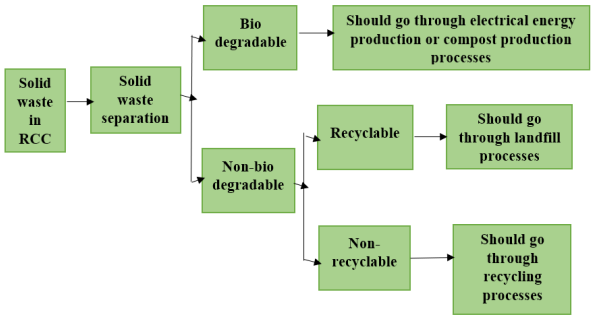

Fig.4 Suggested waste management system in RCC

This process provides much higher electricity than any other fuels, but some additional fuel is required to conduct this process despite rainy season waste drying. Other systems, by comparison, do not have dry land and strong low humidity waste. The best technology in RCC for solid waste management and electricity production may be the incineration technology [6].

12. Conclusion

Waste management in urban areas around the world is a big challenge. The idea of using MSW to produce energy provides good waste management and research progress in the energy crisis. Due to urbanization and GDP growth, MSW has been rising fast in the RCC. WTE recognizes the problem of MSW disposal, while the energy recovery from waste materials has crucial environmental benefits. The presence of Bangladesh in advance of WTE is anticipated to provide other developing countries a few supporting lessons. The findings are given below:

1. The per capita average output of MSW is 1 kg/day.
2. Electric power was measured at about 4.482 MWh / day.
3. The RCC can mount a 5-10 MW power plant.
4. MSW can be used as a source of energy for renewable sources.
5. System output by waste incineration will minimize the costly use of fossil fuel.

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