Sustainable Energy Potential from Different Types of Waste Products

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Abstract Fast depletion of fossil fuels in the world will cause the energy crisis in near future. Due to stringent environmental norms the whole world is focusing on energy from renewable energy sources. Energy from different types of waste in not only renewable but also bring down the cost of disposing the waste from different resources. In this study, five samples of each different types of waste like uneaten food, municipal waste, hospital waste, and cow dung have been focused to recover the energy from these resources. The various samples were tested in laboratory where calorific value and proximate analysis tests were conducted. The study highlighted that cow dung has the highest percentage in terms of mass with approximately 93 and 90% in terms of power that can be recovered. The total energy that can be produced from these wastes amounts to 18.45 MW/day.

Keywords Energy · Power potential · Calorific value · Proximate analysis

1 Introduction

According to United Nations Environment Program, squanders are materials that are not prime items (that is items created for the market) for which the underlying client has no further use as far as his/her own motivations of generation, change or utilization, and of which he/she needs to arrange. Squanders might be created amid the extraction of crude materials, the preparing of crude materials into halfway and last items, the utilization of conclusive items, and other human exercises. Residuals reused or reused at the place of age are prohibited.

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1.1 Types of Waste

- Kitchen Waste—uneaten food.
- Municipal Waste—paper, polythene bag, leaves.
- Cattle Dung—cow dung.
- Hospital Waste—cotton, bandages, plastic syringes, glucose bottles.

1.1.1 Kitchen Waste

The United States Environmental Protection Agency characterizes nourishment squander as “uneaten sustenance and sustenance planning squanders from living arrangements and business foundations, for example, markets, eateries, and create stands, institutional cafeterias and kitchens, and modern sources like representative break rooms”. The states stay allowed to characterize nourishment squander distinctively for their motivations; however, many decide not to kitchen squander, till as of late was not being overseen appropriately but rather it was basically arranged off, which results in landfilling. Kitchen squander contains natural and in addition inorganic issue. The dormant vitality present in its natural part can be recouped for productive use through appropriation of reasonable waste processing and treatment advancements. Squander potential estimations were performed by the Stockholm County Administration Board in the County of Stockholm, both in 2009 and in 2030. This investigation extended the examination and considered the alternative where the biogas from the sustenance squander is used to create power to fuel electric vehicles in Stockholm. The most asset and vitality productive use of the biogas from nourishment waste is converting it to power for electric vehicles [6].

1.1.2 Municipal Waste

A wide range of strong waste produced by families and business foundations are gathered as a rule by nearby government bodies. The arrangement of metropolitan waste fluctuates extraordinarily from nation and changes essentially with time. In nations that have created reusing society, the waste stream comprises essentially immovable squanders, for example, plastic film and unrecyclable bundling. Toward the beginning of the twentieth century, the lion’s share of waste (53%) in UK comprised coal powder from open flames. The waste accumulation is performed by the district inside a given region. The term “Lingering waste” identifies with waste left from family unit sources containing materials that have not been isolated out, in which the diverse kinds of waste resemble plastic, leaves, papers, and sewage slop, etc. [3].

1.1.3 Cattle Dung

Cow compost, otherwise called dairy animals pat, is the waste result of ox-like creature species. These species incorporate household steers ("dairy animals"), buffalo ("bison"), yak, and water wild ox. Cow excrement is the undigested buildup of plant matter which has gone through the creature's gut. The resultant fecal issue is wealthy in minerals. Shading ranges from greenish to blackish, regularly obscuring not long after introduction to air. It is additionally known in the American southeast and west as "dairy animals pies". If not reused into the dirt by species, for example, night crawlers and waste creepy crawlies, cow manure can dry out and stay on the field, making a region of munching land which is unpalatable to domesticated animals. In numerous parts of the creating scene, and in the past in mountain districts of Europe, hardened and dried cow manure is utilized as fuel. Excrement may likewise be gathered and used to create biogas to produce power and warmth. The gas is wealthy in methane and is utilized in country zones of India/ Pakistan and somewhere else to give an inexhaustible and stable wellspring of power. The capability of vitality recuperation from provincially accessible agro and family unit natural squanders and accordingly, the conceivable effect on enhancing vitality request, diminishing deforestation, and supplanting nonrenewable energy source and also maintained a strategic distance from ozone harming substances. Results demonstrate that co-assimilation of an extensive variety of excrement, edit buildups, and family unit squanders with dairy animals fertilizer was effective to deliver expanded gas yield than what might be if cow compost is processed independently and the vitality esteem from this can enhance 57–79% of the provincial interest contingent upon methane yield from natural waste blends. It has been proposed that execution of co-assimilation in the concentrated plant could be a suitable answer for delivering decentralized vitality for the rustic family units as far as maintainable waste administration, lessening deforestation, and in addition supplanting fossil fuels [5].

1.1.4 Hospital Waste

Doctor's facility squander is characterized as all squanders produced from medicinal services or well-being related offices. It is naturally heterogeneous, comprising objects of a wide range of sizes and made out of various materials. As indicated by World Health Organization (WHO) gauges 85% of doctor's facility squander is really non-dangerous and around 10% is irresistible while the remaining 5% is non-irresistible yet comprises unsafe synthetic concoctions like methyl chloride and formaldehyde [4]. In the aggregate sum of city squander, a city produces just 1–1.5% healing center wastes, of which 10–15% is considered infectious [1].

2 Materials and Methods

The methodology adopted for the study is outlined below:

- Preparation of Questionnaires
- Data Collection
- Collection of Waste Samples
- Testing of Samples
- Result and Conclusion.

2.1 Preparation of Questionnaires

A questionnaire has been designed to assess the overall quantity and quantity of different types of hospital waste in Mullanpur city. Quantitative approach has been used to tape the perception of the individual respondent. The questionnaire contains seven questions related to type and quantity of waste.

2.2 Data Collection

Both primary and secondary data has been used for the study. The data has been collected from the hospital employees in the form of responses to the questionnaire. The data has been collected by personal visits to the hospitals. This includes personal meetings with hospital employees. The data related to municipal waste was obtained from Municipal Council Mullanpur Dakha and Data regarding quantity of cow dung was obtained from Gaushala.

2.3 Collection of Waste Samples

Five samples of each different type of hospital waste like cotton, bandages, plastic syringe, and glucose bottles in different conditions have been taken from hospital. Samples of municipal waste were collected from dumping site and the sample of cow dung was collected from Gaushala. Collected samples in different conditions were collected and taken to laboratory for experiments.

2.4 Testing of Samples

Gathered examples have been tried in research facility where calorific esteem and proximate examination tests were directed. Calorific esteem test gives the measure of potential vitality that can be changed over into real warming capacity. It has been found by utilizing device known as Bomb Calorimeter. The proximate examination test gives the four parameters, i.e., dampness content, unstable issue, fiery debris content, and settled carbon.

2.4.1 Proximate Analysis

The proximate analysis is done for the determination of

1. Moisture Content
2. Volatile Matter
3. Ash
4. Fixed Carbon

Moisture Content

The value of moisture content has been obtained by heating the sample at 105 °C in muffle furnace.

Mathematically it is given by

$$\%\ \text{moisture} = \frac{X1 - X2}{X1 - X} \times 100 \qquad \text{(eq.1)}$$

X1 = weight of crucible + weight of sample
X2 = weight of crucible + weight of sample after heating
X = weight of empty crucible.

Volatile Matter

The value of volatile matter has been obtained by heating the sample at 915 °C for 7 min. The difference in weights of sample before heating and weight of sample after heating gives net value of volatile matter.

Mathematically it is given by

$$\%\ \text{volatile matter} = \frac{X1 - X2}{X1 - X} \times 100 \qquad \text{(eq.2)}$$

Ash

The value of ash content has been obtained by heating the sample at 630 °C for 2–3 h. The difference in weights of sample before heating and weight of sample after heating gives net value of ash content.

Mathematically it is given by

$$\%\ \text{ash} = \frac{\text{X1} - \text{X2}}{\text{X1} - \text{X}} \times 100 \qquad \text{(eq.3)}$$

Fixed Carbon

The value of fixed carbon has been obtained by subtracting % age value of all above from 100.

Mathematically it is given by

$$\%\ \text{fixed carbon} = 100 - (\text{eq.1} + \text{eq.2} + \text{eq.3})$$

2.4.2 Calorific Value Test

Calorific esteem is the measure of potential vitality that can be changed over into real warming capacity. This warming capacity gives the estimation of vitality that can be recuperated. The calorific esteem is found by utilizing contraption known as Bomb Calorimeter.

3 Results and Discussion

3.1 Municipal Waste Generation Rates

From Municipal Council Mullanpur Dakha it was observed that generation rate of plastic was highest with 102 kg/day, paper with 73 kg/day, and leaves having 25 kg/day. Municipal waste generation rates are mentioned in Table 1.

Table 1 Municipal waste generation rates

Sr.No.	Type of waste	Quantity of waste/day (kg)
1.	Paper	73
2.	Polythene bag	35
3.	Leaves	25

3.1.1 Classification of Municipal Waste (Mass %)

Quantitative analysis of municipal waste shows that plastic waste has the highest percentage in terms of mass with 51%, paper, the next highest has 37%, and leaves with 12% in terms of mass (Fig. 1).

3.2 Hospital Waste Generation Rates in Surveyed Hospitals

To calculate the generation rate per patient per day, the total waste generated per day of hospital was calculated then divided by number of patients per day [2]. The diagram shows that the medical waste generated from "Deol Hospital" is small and medical waste of "Sant Nursing Home" is large as compared to other hospitals. The average medical waste generated per patient per day is 1.28 kg (Fig. 2).

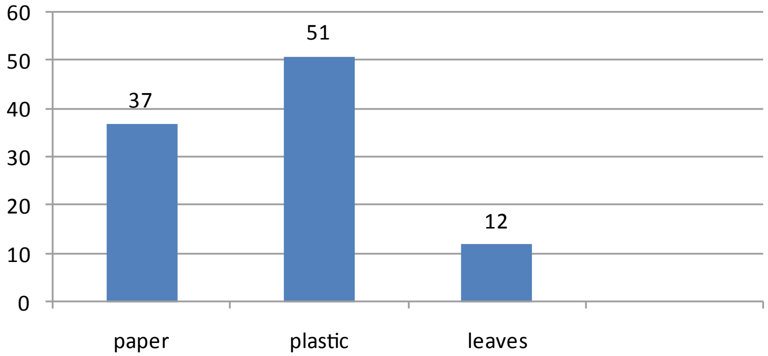

Fig. 1 Municipal waste assessment

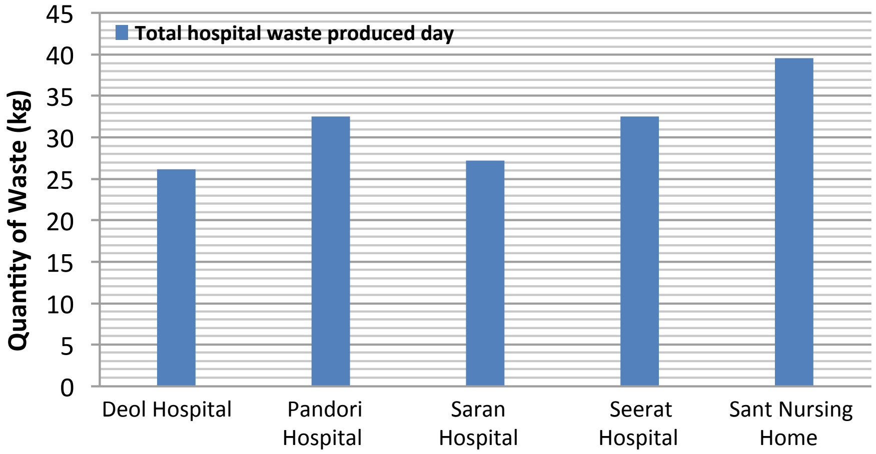

Fig. 2 Hospital waste generations in surveyed hospitals

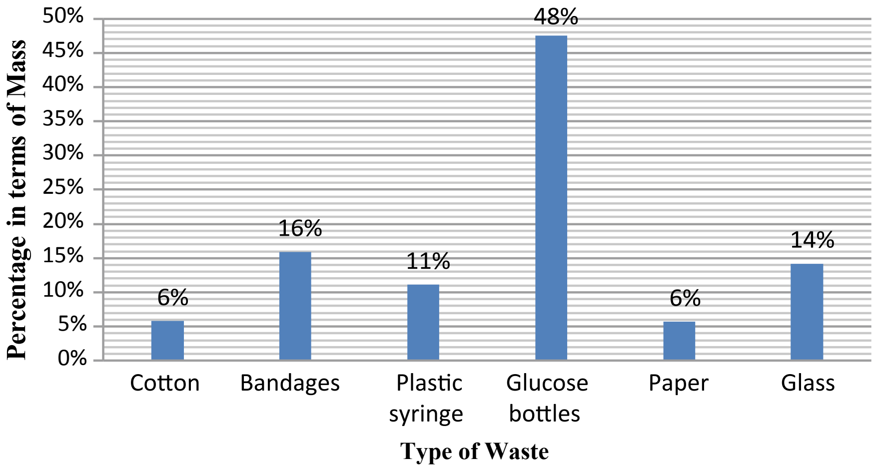

Fig. 3 Classification of hospital waste in surveyed hospitals (mass %)

3.2.1 Classification of General Healthcare Waste (Mass %)

The following diagram shows that total cotton waste of surveyed hospital is 9.2 kg/day, total bandages waste is 25.1 kg/day, total plastic syringe waste is 17.4 kg/day, total glucose bottles waste is 75.0 kg/day, total paper waste is 9.0 kg/day, and total glass waste is 22.3 kg/day. Average generation rate of cotton is 1.8 kg/hospital/day, for bandages 5.0 kg/hospital/day, for plastic syringe 3.5 kg/hospital/day, for glucose bottles 15 kg/hospital/day, for paper 1.8 kg/hospital/day, and for glass 4.5 kg/hospital/day (Fig. 3).

Quantitative and Qualitative analysis of hospital waste shows that glucose bottles have the highest percentage in terms of mass with 47.5%, bandages, the next highest has 15.9%, glass with 14.2%, plastic syringe with 11.1%, cotton with 5.8%, and **region**: On surveying the region it has been found that quantity of uneaten food was 34 kg/day.

3.3 Quantitative Assessment of Cow Dung from Gaushala

On visiting the Gaushala, it has been found there were 350 cows and average dung produced by each cow per day was approximate 11 kg, and hence total Cow dung per day from Gaushala has been obtained (Table 2).

Table 2 Quantitative assessment of cow dung from Gaushala

No. of cows in Gaushala	Average dung obtained/cow/day (kg)	Total dung/day (kg)
350	11	3850

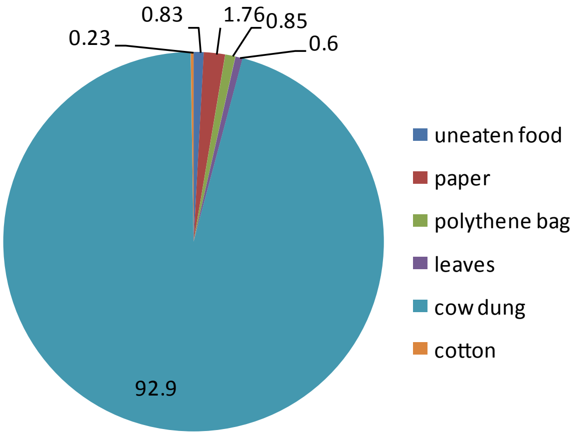

Fig. 4 Quantitative assessment of selected squander in terms of percentage

The generation of cow dung from Gaushala is 3850 kg/day and the average dung obtained is 11 kg/cow/day (Fig. 4).

The cow dung is 92.9% of the overall waste, uneaten is 0.83%, paper is 1.76%, polythene bag is 0.85%, leaves are 0.6%, and cotton is 0.23% of the overall waste.

3.4 Calorific Value Test

3.4.1 Calorific Value Test of Hospital Waste

The experiment of calorific value on selected hospital wastes shows that calorific value of plastic syringe is highest which is 42740 kJ/kg, glucose bottles contain 39840 kJ/kg, bandages have 18030 kJ/kg, and cotton contains 15190 kJ/kg of energy. The calorific value is found by using apparatus known as Bomb Calorimeter (Fig. 5).

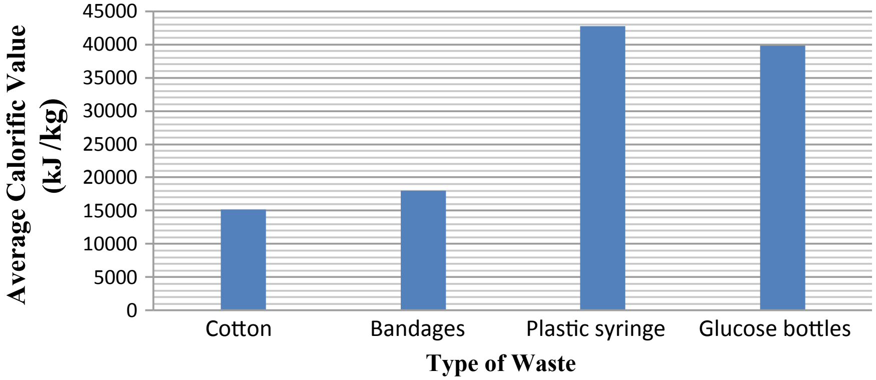

Fig. 5 Average calorific value content in selected hospital wastes

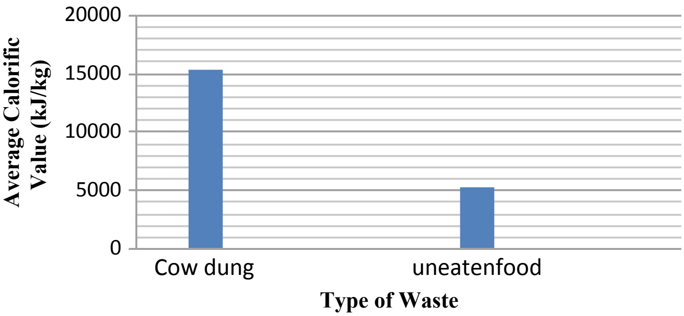

Fig. 6 Average calorific value of uneaten food and cow dung

3.4.2 Calorific Value Test of Kitchen Waste and Cattle Dung

The experiment of calorific value on selected cattle dung shows that calorific value of cow dung is highest which is 15472 kJ/kg and uneaten food contains 5208 kJ/kg of energy. The calorific value is found by using apparatus known as Bomb Calorimeter.

3.4.3 Calorific Value Test of Uneaten Food and Cow Dung

See Fig. 6.

3.4.4 Calorific Value Test of Municipal Waste

The experiment of calorific value on selected municipal waste shows that calorific value of polythene bag is highest which is 27140 kJ/kg, leaves contain 16370 kJ/kg, and paper has 13840 kJ/kg of energy. The calorific value is found by using apparatus known as Bomb Calorimeter (Fig. 7).

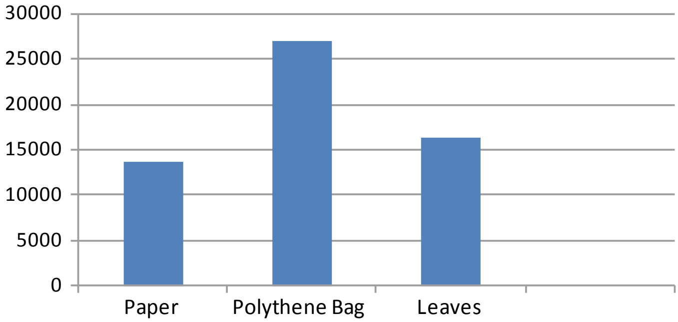

Fig. 7 Average calorific value of municipal waste

Table 3 Energy potential calculations

S. No.	Waste	Generation rate/day (kg)	Average calorific value (MJ/kg)	Energy (MJ)	Power (MW)
1.	Uneaten food	34	5.20	176.8	0.05
2.	Paper	73	13.84	1010.32	0.28
3.	Polythene bag	35	27.14	949.9	0.26
4.	Leaves	25	16.37	409.25	0.11
5.	Cow dung	3850	15.47	59559.5	16.54
6.	Cotton	9.2	15.19	139.74	0.03
7.	Bandages	25.1	18.03	452.55	0.12
8.	Plastic syringe	17.4	42.74	743.67	0.20
9.	Glucose bottles	75	39.84	2988	0.83
	Total			66429.98	18.45

3.5 Calculation of Energy Potential from the Selected Waste

See Table 3.

4 Conclusions

- The ponder featured that amount of waste is expanding quickly, it is smarter to execute a vitality recuperation venture instead of burn or dumping of waste.
- The contribution of cow dung in terms of power was 90% out of total power.

Appendix—I

(Questionnaire)
This questionnaire contains quantitative questions, kindly read carefully the questions and enter your response in the space provided.

This questionnaire contains quantitative questions, kindly read carefully the questions and enter your response in the space provided.

Q1. Name of the hospital. ________________________

Q2. Type of hospital:

a) Speacialist b) Multi-Specialist

Q3. Number of beds in hospital. ________________________

Q4. Number of patients per 24hrs. ________________________

Q5. Total medical waste produced per day in hospital:

a) upto 20kg b) 21-40kg c) more than 40kg

Q6. Total medical waste produced per bed/day in hospital:

a) upto 1kg b) 1-2kg c) more than 2kg

Q7. Quantity of following waste produced per day:

a) cotton ________kg b) bandages ________kg
c) plastic syringe _____kg d) glucose bottles _______kg

References

1. Akter, N., Trankler, J.: An analysis of possible scenarios of medical waste management in Bangladesh. J. Manag. Environ. Qual. **14**(2), 242–255 (2003)
2. Altin, S., Elevli, B.: Determination of hospital waste composition and disposal methods. Pol. J. Environ. Stud. **12**(2), 251–255 (2003)
3. Alamgir, M., Ahsan, A.: Municipal solid waste and recovery potential: Bangladesh perspective. J. Environ. Health. Sci. Eng. **4**(2), 67–76 (2007)
4. Azage, M., Kumie, A.: Healthcare waste generation and its management system: the case of health centres in West Gojjam Zone, Amhara Region, Ethiopia. Ethiop. J. Health Dev. **24**(2), 119–126 (2010)
5. Ashekuzzama, S.M.: Supplementing energy demand of rural households in Bangladesh through appropriate biogas technology. In: International Conference on Environmental Aspects of Bangladesh (2010)
6. Curry, N., Pillay, P.: Biogas prediction and design of a food waste to energy system for the urban environment. J. Renew. Energy **41**, 200–209 (2011)