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Treatment and Energy Benefit from Hospital Wastes Incineration (Case Study in Albania)

EDMOND DEMOLLARI[1*], NDOC VATA[1]

[1]Agricultural University of Tirana, Faculty of Agriculture and Environment, Tirana, 1029, Albania

*Correspondingauthor; E-mail: edemollari@ubt.edu.al

Abstract

Energy, as one of the most observed topics, can be obtained in different ways, from traditional to renewable. This energy process is one way of utilizing unrecyclable waste and minimizing volumes going to landfills. The treatment of hospital waste helps reducing infections as well as gaining energy from the process of burning. Proper management of hospital waste requires special treatment, such as incineration or disposal of hazardous waste. Hospital waste is "Any waste which is generated in the diagnosis, treatment or immunization of human beings or animals or in research" in a hospital. The hospital wastes must be collected and stored separately in containers of adequate capacity ensuring no spillage during transport. Hospital waste management in selected facilities represents a big environmental health issue, as well as other basic sanitation aspects like drinking water supply and wastewater management. The quantities of electricity benefited from the treatment and incineration of plastic hospital waste considered in this study originated from three national hospitals: "Koço Gliozheni" Gynecological Hospital in Tirana 150,39 kW/Year (2017); 172.8 kW/Year (2018); 202.1 kW/Year (2019); 720 kW/Year (2020), Hospital of "Durrës" City 544.5 kW/Year (2017); 630 kW/Year (2018); 769.5 kW/Year (2019); 831.6 kW/Year (2020) and Hospital of "Kukës" City 360 kW/Year (2017); 189.48 kW/Year (2018); 330 kW/Year (2019); 150 kW/Year (2020)..

Keywords: Electricity; hospital wastes; incinerator; Mediburn-30;

1. Introduction

The world is generating more and more waste and hospitals and health centers are no exception (Red Cross et al., 2011). Medical waste can be infectious, contain toxic chemicals and pose contamination risks to both people and the environment (Red Cross, 2011). The incineration of substances contained in waste materials of different natures is a waste treatment. According to the concept of sustainable waste disposal, a successful treatment of Medical Waste should be safe, effective, and environmentally friendly (WHO, 2008). Hospital waste is a special type of waste produced in small quantities carrying a high potential of infection and injury (Rasheed, Iqbal, Baig, Mufti 2005). Medical waste is limited to infectious, hazardous, and any other wastes that are generated from health care institutions, such as hospitals, clinics, dental offices, and medical laboratories (US Congress, Office of Technology Assessment, 1988). The management of medical waste has been of major concern due to potentially high risks to human health and the environment. In the past, medical wastes were often mixed with household wastes and disposed in municipal solid waste landfills (Zarook M. Shareefdeen, 2012). However, recycling of plastic hospital waste presents an opportunity for generation of energy. Researchers have studied the waste characterization, waste-to-energy sizing, and viability of a waste-to-energy plant (F. Manegdeg et al. 2020). Waste contains a significant energy amount stored in the chemical bonds in its components; its

*Corresponding author: Edmond Demollari; E-mail: edemollari@ubt.edu.al
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conversion into a reusable form could provide a means to supply clean energy and contribute to solving the waste global problem (C. Arcuri, F. Luciani, P. Piva, F.N. Bartuli, L. Ottria, B. Mecheri and S. Licoccia, 2013). The energy carried by these wastes, mainly plastics, can help replenish the missing energy. According to Alexander H. Tullo, 1400 tons of plastic waste generates superheated steam up to 450 °C, which drives a turbine connected to a generator that produces electricity up to 42 MW (https://cen.acs.org/ environment/sustainability/Should-plastics-source-energy/96/i38). Generating energy from these plastic wastes is seen as a good option. There are two reasons. The first reason is related to the time of plastic recycling in the ground. Studies show that plastic waste decomposes over a period of about 50 years. The second reason is related to the generation of thermal energy. Based on the study of Alexander Tullo, 1400 tons of plastic waste, generate superheated steam up to 450 °C, which activate the turbines which generate up to 42 MW of electricity (or simply put: 1 kg of plastic waste generates up to at 30 W power).

2. Material and Methods

The three main hospitals studied are: "Koco Gliozheni" Gynecological Hospital in Tirana, Hospital Durres City and Hospital of Kukës City. The largest concentration of population is in the Tirana-Durres area. Automatically and larger hospital services are in these areas. The Gynecological Hospital "Koco Gliozheni" in Tirana has had an increase in the generation of hospital waste with plastic nature. The device that helps hospitals in eliminating their wastes (mainly plastic waste) is MEDIBURN-30. The MEDIBURN-30 incinerator is environmentally safe, compact and easy to use (Figure 1). This incinerator operates on petroleum fuels for the treatment of hospital waste, in: hospitals, clinics, pharmacies, laboratories, blood banks and veterinary clinics and reaches a maximum temperature of 1000°C. MEDIBURN-30 is capable of disposing of up to 0.29 m3 of infectious and pathological waste loads (mainly plastics), with a burning rate of up to 30 kg/h. Waste treated includes everything from medical waste to animal waste. It operates with two-stage modulated combustion and pressure technology. Its control is electronic, updated security and self-control system. The small size of the incinerator makes it easy to fit in limited spaces. Portability and easy installation provide ease of relocation. The sterilization-disposal method of hospital wastes is based on the combined application of two processes: mechanical-thermal and incineration.

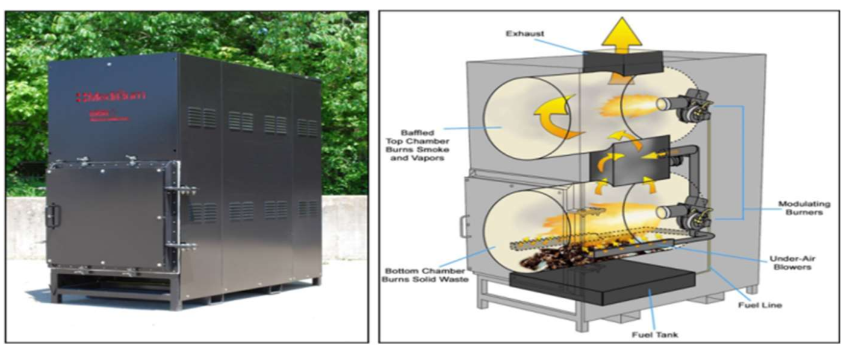

Figure1. The incinerator Mediburn-30 (www.elastec.com)

The mechanical-thermal process consists of breaking into smaller pieces of waste by means of two cutting drums that rotates in opposite directions to each other, while the thermal process consists of the combined application of temperature (for removing residual moisture) and high pressure (to eliminate bacteria). Incineration is a thermal waste treatment technique that can be understood as a controlled combustion process with the primary objective of volume reduction and energy recovery from the waste stream (https://www.sciencedirect.com/topics/chemistry/incineration). The incineration method consists of the final combustion of waste-producing at the same time thermal energy converted into electricity.

2.1. Plastic properties

Many of the chemical names of the polymers employed as plastics have become familiar to consumers, although some are better known by their abbreviations or trade names. Thus, polyethylene terephthalate and polyvinyl chloride are commonly referred to as PET and PVC, while foamed polystyrene and polymethyl methacrylate are known by their trademarked names, Styrofoam and Plexiglas (or Perspex). Industrial fabricators of plastic products tend to think of plastics as either “commodity” resins or “specialty” resins. Commodity resins are plastics that are produced at high volume and low cost for the most common disposable items and durable goods (www.philadelphia.edu.jo). They are represented chiefly by polyethylene, polypropylene, polyvinyl chloride, and polystyrene. Specialty resins are plastics whose properties are tailored to specific applications and that are produced at low volume and higher cost. Among this group are the so-called engineering plastics, or engineering resins, which are plastics that can compete with die-cast metals in plumbing, hardware, and automotive applications. Important engineering plastics, less familiar to consumers than the commodity plastics listed above, are polyacetal, polyamide (particularly those known by the trade name nylon), polytetrafluoroethylene (trademark Teflon), polycarbonate, polyphenylene sulfide, epoxy and polyetheretherketone.

2.2. Energy Output Estimation and Power Generation Potential from waste plastics

The values of the content of the elements in the plastic waste have been determined from the standard and dry mass tables of the sample taken in the study. The values found were used in Dulong's equation (www.philadelphia.edu.jo /academics/abadran/uploads/2%20%20Chapter-2.pdf), which determined the energy content, Higher Heat Value (HHV):

$$HHV\ (MJ/kg) = 337C + 1419\{H_2O - 0.125O_2\} + 93S + 23N$$

From the study of (Franjo, Ledo, Rodriguez & Nunez, 1992) it was shown that HHV was defined as the heat generated by the complete combustion of a unit of material in the presence of air or oxygen. This study also showed the term of Lower Heat Value (LHV):

$$LHV\ (kcal/kg) = HHV - 9H * LHS$$

Where:

LHV = Lower Heat Value;

HHV= Higher Calorific Value;

LHS = Latent Heat of Steam which is 587 (kcal/kg);

H = Hydrogen (%).

3. Results and Discussion

In many cities of Albania, hospitals are one of the main sources of plastic waste generation. The three hospitals included in the study generate large amounts of waste per year. (see table 1). These wastes can be used as raw material or fuel to generate electricity. Based on the data from the hospitals, the year 2020 marked the largest increase in the generation of hospital waste. There are two main reasons: the highest number of urban population concentration in the Tirane-Durres axis, and the time of the COVID-19 pandemic. This study tries to show how to collect, treat and gain energy from plastic waste, using the sterilization-disposal method. This method, divided into two mechanical-thermal processes and the incineration process, helped to reduce the amount of waste but also the production of electricity. Calculations of energy gain from waste were determined by the equation from Dulong's equation. This determined the highest heat value (HHV), based on the masses of the constituent elements of the plastic, from the complete combustion of the mass unit in the presence of oxygen.

Figure 2. Cities where hospital waste was taken into study

Table 1. Amount of hospital waste generated by hospitals (in years)

	Year	2017	2018	2019	2020
"Koço Gliozheni" Gynecological Hospital	**(Ton/Year)**	5.02	5.76	6.73	24
Hospital of "Durrës City"	**(Ton/Year)**	18.1	21	25.7	27.72
Hospital of "Kukës City"	**(Ton/Year)**	12	6.316	11	5

This study also showed the lowest heat value (LHV), as the net heat produced when the unit of mass is completely burned in the presence of oxygen, the products of which leave in the form of vapors. The final determination of the PGP equation expressed the amount of electricity produced by the generation of steam from plastic waste (see figure 3). Based on mathematical calculation, Chart 1 shows the total quantities of hospital waste for the years 2017-2020. From the graph we see that the hospital of Durres has generated more quantities of hospital waste, respectively in 2017 (18150 kg), 2018 (21000 kg), 2019 (25650 kg) and 2020 (27718 kg). The Gynecological Hospital "Koco Gliozheni" in Tirana has had an increase in the generation of hospital waste with plastic nature, and this is more noticeable in 2020. From 2019 to 2020, the amount of waste has increased four times more. The reason is that during the peak period of the pandemic time, the hospital service increased exponentially. Figure 3 shows a clear overview of the possibilities of generating electricity that we could get from this plastic waste. Hospital waste, mainly plastic waste, is one of the main sources for the operation and profit of electricity.

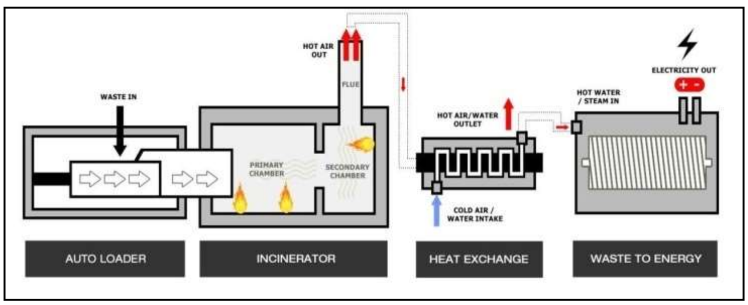

Figure 3. Scheme of profit of electricity from waste incineration (www.inciner8.com)

Initially, plastic hospital waste is selected and weighed. The reason for weighing is to determine the moisture they contain. They are loaded into the autoloader (Autoloader) and transported to the incinerator (Incinerator). This one is made up of two rooms (humidity removal room and incineration room). The primary chamber functions as a dryer for the base material. The removal of moisture greatly facilitates the work for the second process.

Table 2. The percentage waste plastics in three hospitals.

Sample Name	Waste plastics dry season %	Waste plastics wet season %	Waste plastics mean (%)
Sample 1	16.42	18.15	17.285
Sample 2	18.6	20.63	19.615
Sample 3	19.97	21.59	20.78

Table 3. Proximate analysis results of waste plastics

Waste type	Wet mass (kg)	Dry mass (kg)	Moisture Content (%)	Moisture content (gr)
Plastic	0.03	0.0297	2.84	0.0003

Table 4. Elemental Composition (in %) for waste plastics.(Tchobanoglous et al. 1993)

Waste type	Carbon %	Hydrogen %	Oxygen %
Plastic	60	7.2	22.8

Table 5. Final analysis results of waste plastics from three hospitals

Waste type	Wet mass (gr)	Dry mass (gr)	Moisture content (gr)	C (gr)	H (gr)	O (gr)	Ash (gr)
Plastics taken from ("Koço Gliozheni" Gynecological Hospital)	22	21.59	0.41	12.96	1.35	4.284	2.996
Plastics taken from (Hospital of "Durrës City")	31	30.46	0.54	19.47	1.93	3.961	5.099
Plastics taken from (Hospital of "Kukës City")	25	24.51	0.49	15.73	1.04	4.39	3.35

Table 6. Total quantities of electricity power for each hospital

	Year	2017	2018	2019	2020
"Koço Gliozheni" Gynecological Hospital	Total (kW)	150.39	172.8	202.1	720
Hospital of "Durrës City"	Total (kW)	544.5	630	769.5	831.6
Hospital of "Kukës City"	Total (kW)	360	189.48	330	150

This enables the realization of the burning of the plastic material up to the maximum of the material. Knowing that the plastic material contains up to 60% C, it means that the heat obtained is enough to turn the water into superheated steam from the heat exchanger device (Heat Exchange). Based on the thermodynamic principle, this amount of steam has enough energy to set the steam turbine in motion. The number of rotations of the turbine shaft are transferred and simultaneously transformed into electricity production in the generator (Waste to Energy).

4. Conclusions

In conclusion, the generation of electricity from waste of plastic nature, not only eliminates large amounts of waste that would take a long time to be recycled or applied a method to destroyed bacteria or viruses but also gives us the opportunity to benefit from the process of their incineration. The study showed that hospital of Durres City in 2020 has managed to produce the largest quantities of hospital waste in the amount of 27719 kg (see table 1), which produced electricity in the amount of 831.6 kW (see table 6). Knowing that Albania produces electricity 100% from hydropower plants (with water supply from the Mountain Rivers), it is directly dependent on the amount of annual rainfall in the country. If these wastes are well managed, we will have a cleaner environment, with high hygiene, and electricity will be obtained many times and more. The same methodology will be applied in other hospitals of Albania, in order to treat wastes and calculation of energy production. This would greatly help the energy situation in the event that Albania will face a lack of rainfall in the country.

5. Acknowledgements

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