International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-07, Issue-05, AUG 2021

Green Energy Generation from Municipal Waste as Novel Technique

Dr. Santosh Kumar, Assistant Professor, G H Raisoni College of Engineering & Management, Pune, Maharashtra, santosh.kumar@raisoni.net

Dr. Premendra Bansod, Associate Professor, G H Raisoni College of Engineering & Management, Pune, Maharashtra, premendra.bansod@raisoni.net

Abstract -Human beings are always seeking for a better life. There is movement of people from rural to urban regions due to industrial and financial growth. Rapid industrialization and urbanization are resulting in rise of the production of metropolitan discarded. In India, as per the report of the Press Information Bureau, it gives out more than 62 million tonnes of waste (both biodegrable waste & non biodegrable waste) per year. More than 80% of municipal waste is disposed of unhygienic manner which leads to environmental problems and health issues. There is big challenge to overcome the generation of municipal garbage in the light of inadequate accessibility of final disposal sites in many part of the world. These issues led to serious community worries, later on turns resulting in political actions targeting to overcome the quantity of garbage reaching in our atmosphere. These are the objectives to encourage ecological garbage managing solutions. In developing countries like India, waste collection, transportation and finally disposal is still a big challenge while, in developed countries, emerging technologies are used for transformation of garbage to sustainable energy and valued chemical products. There is a need for suitable and sustainable technology which converts municipal waste into useful products in light of statutory regulations pollution control standards. This review article through light on different waste-to-energy technologies developed till date forenvironmental and public health concern.

Keywords: Municipal Waste, Waste Management, Emerging Technology, Sustainable Energy

I. INTRODUCTION

Presently, there are different types of waste which are as follows:

- Metropolitan solid waste (MSW)
- Practice waste
- Medicinalwaste&Cultivated waste

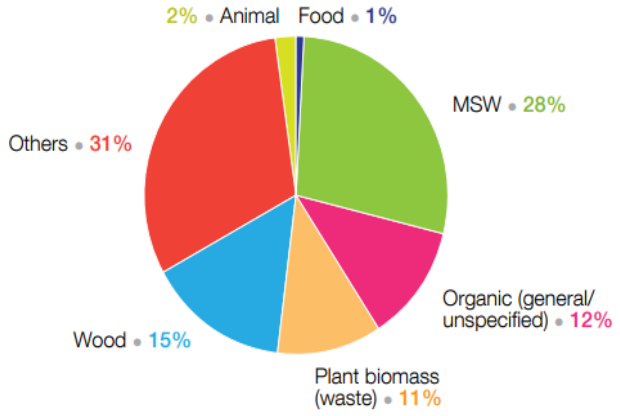

Fig. 1: Usefulness Units of Different Raw Materials

It is expected that the worldwidegarbage production will be around 6 million tonnes/day by 2025 as per observation of the current waste generation as the report of the World Energy Council (2016). Figure 1 shows the creative dealing with various wastesfor better usefulness from waste to energy consuming MSW or agricultural waste.Ineffective dealing with municipal waste causes threat to lives and nature.The ineffective dealing with municipal issue can be resolved by joint methodology containing the 3Rs (Reduce, Reuse and Recycle). India has hosted the 8th 3R Regional Forum in Asia, in one of its cleanest city, Indore(in the annual cleanliness survey conducted by the Ministry of Housing and Urban Affairs, Indore & Mysore got opportunity to stood as no. 1 city in Swachh Survekshan 2016, 2017 and 2018) from 9 April to 12 April in year 2018. The Ministry of Housing and Urban Affairs (MoHUA) Government of India, the Ministry of the Environment, Government of Japan (MOEJ) and the United Nations Centre for Regional Development (UNCRD) co-organized it.The theme of 8th 3R Regional Forum was "Achieving Clean Water, Clean Land and Clean Air through 3R and Resource Efficiency- A 21st Century, it was Vision for Asia-Pacific Communities".

Social-economic development and the degree of industrialization and climate have caused the growth rate of municipal garbage. Usually, the density of people increased due to migration from rural to urban area and rapid industrialization result to the greater amount of garbage

 DOI : 10.35291/2454-9150.2021.0448

(waste) production which lead the social-economic and environmental problems [1].In general, waste management is a vast challenge in respective of seeking the opportunity based on its derived products [2].The climate, energy sources, culture and financial growth affect the municipal waste generation and its configuration from country to country. Although developing countries generate highest quantity of organic waste whereas in developed countries inorganic materials are the main component of municipal waste [3].As per the estimated report of The World Bank around1.32 billion tonnes of garbage produced every year globally and the quantity will rise to 2.22 billion tonnes annually by 2025 [4].These data reflect light on very serious environmental issues and requirement of global policies to overcome the rise of urban waste production in the whole world. While in the developed countries wastes are recycled for the production of heat, energy and fuel whereas transportation, collection and disposal of urban waste are the big challenges in low income nations [5, 6].Generally, the municipal corporations which are unable to disposeits waste properly rarely able to handle most offering services like health, education, transportation or electricity.Traditional methods(including landfilling,incineration and composting) for treatment of municipal garbage'shave many demerits regarding environmental concern.While disposing municipal waste in landfills have very serious environmental problems like bad smell, generation of leachate, spread of pathogenic bacteria,which affect the underground waterand soil and liberation of high volume of methane gas which have more than 20 times greater greenhouse gas potential than CO_2 [7,8].This can be understand by taking a suitable example, more than 95% of waste (including 25.1% food waste and 70.2% municipal solid waste) decomposes in landfills, which creates a calamitous condition in the environment due to release of greenhouse gases and methane (124.8 m^3 estimated gaseous volume per tonne of food waste) [9, 10].Wastematerials are used to produce heat and energy. Though burning waste is anesteemed process, more for remote areas, but it can cause environmental pollution [it involved the formation of persistent organic pollutants (POPs) and dioxins)] and the loss of opportunities to create valuable chemical products from the various waste [10,11]. Also, incineration of waste causes air pollution due to the generation of fly ashes which have to be safely cleared and it involves high investment and operating cost [12]. Composting is the process where ethnic microorganisms are used as environmentally friendly fertilizers and to stabilize organic materials. If, the composting methodis not proceed carefully then composting might result in consequencessuch as bad smelland production of greenhouse gases [10]. However,the attention of both scientific and public opinion has been gained bythe potential of valorization of the wastes to produce essential fuels and valuedchemical products. The previous investigation through light that refuse-derived fuels based on municipal solid waste exhibit lower release of POPs during combustion and the quality of fuel enhances when it is derived from wide separation of food wastes from the households [13, 14].

II. Current Issues for Waste Management in India

It's due to unscientific management, incorrect collection of waste and ethical difficulties. This leads to hazards like environmental degradation, air & water pollution. The following are some facts which show the hazardous impact of waste faced by Indian Societies.

Fig.2 Garbage Dumping Site at Uruli Devachi Pune Maharashtra

Fig.3 Garbage bins outside a residential block in VasantVihar, Delhi

Fig.4 Huge Dome of Garbage at Ghazipur, Delhi, India

Fig.5 Separatingwastes a top a mound of garbage at a landfill in Delhi

As per the record of 2017 & 2018, it is estimated by Central Pollution Control Board (CPCB) that India produces about 9.41 million tonnes of plastic waste every year, (that means 26,001tonnes of plastic garbage every day) and every year

 DOI : 10.35291/2454-9150.2021.0448

only 5.7 million tonnes of plastic garbage is recycled (i.e. 15,601tonnes of garbage every day) while every year 3.7 million tonnes ofplastic garbage is left littered or uncollected (i.e. 9,401tonnes of waste every day). Out of the 60% of recycled plastic garbage, 71% of garbage is recycled at registered facilities, 10% of garbage is recycled at home, and 19% of the plastic garbage is recycled by unorganized sector. While these data are 38.01% higher than the global average of 22%, for Plastic Waste Management, there are no comprehensive methods. Also, there is anuncontrollablerise in plastics garbageproduction. One of the major causes of uncontrollable rise in plastic waste management is that 51% of plastic is discarded as waste after single use. This also enhances the increase in the carbon footprint since only single use of plastic creation brings rise in the call for virgin plastic creation.

Government of India has informed recently Plastic Waste Management Rules, 2016. As per the Rule, every Municipal Corporation and the authorities in the rural area have been requested to recycle, reuse and handle the plastic in such a way that no harm is caused to the environment. The rules have been put in place for appropriatemanagement and recycling it if that is not done the agency will be fined. In all the coastline area and aquatic environment, the same rules are applicable.

III. Global Scenario of Utility Scale Plants

Fig. 6 shows the energy generation by combustion/incineration still plays a vital role of technology used whereas biogas, biofuel and gasification are still in the marginal.

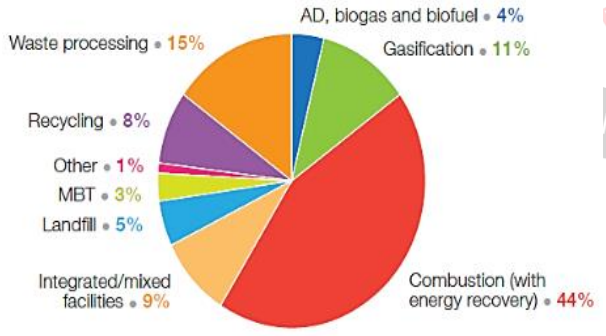

Fig. 6: Global scenario of utility scale plants by use of the existing technology (93 countries' data of year 2013-2014 (total of 2722 facilities)). *(Mechanical Biological Treatment-MBT)

IV. Waste to Energy Benefits

India has recently started converting waste to energy. Conversion of waste into energy will result to overcome the environmental pollution, land dumping, greenhouse gas emissions and fossil fuel usage. Emerging technological methods are applied to produce energy from garbage minimizing the country's dependency on expensive and vulnerable (nonrenewable) petroleum resources. It has been observed that due to the use of garbage as feedstock for power generation has decreased the litter generated by combustion of nonrenewable fuel. Old-fashioned way of burning fire produces CO_2& pollutants.The purpose to eliminate CO_2 from raw biogas is that, biogas can be observed from waste landfills which contain 54% methane, whose calorific value is 21.6MJ/ Nm^3, whereas pure methane has a calorific value 35.8 MJ/ Nm^3. The amount of energy released by the combustion of biogas is very essential to replace the place of burnable gas and exemplifies the calorific value that can be switched by CH_4 (Fig. 7-b).Dual benefits can be provided by extra-ordinary methods, such as-gasification, liquefaction and pyrolysis. The dual benefits obtained from the innovative methods are (i) Reduction in the amount of carbon dioxide in incineration and coal plant, (ii) Reduction in the release of CH_4 from landfills. Large amount of land is required for landfill which would be utilized for different reasons. Also, the burning of the municipal garbage produces energy and reduces 80% volume of the solid garbage.

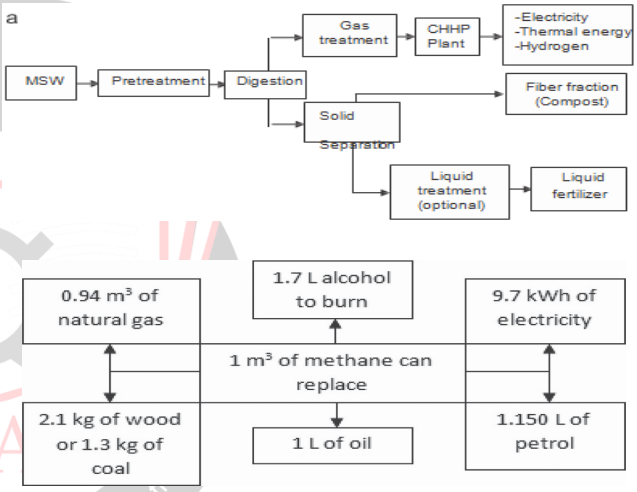

Fig. 7(a)Illustrates (i) Treatment of MSW by anaerobic digestion(ii) Energy correspondence of CH4.

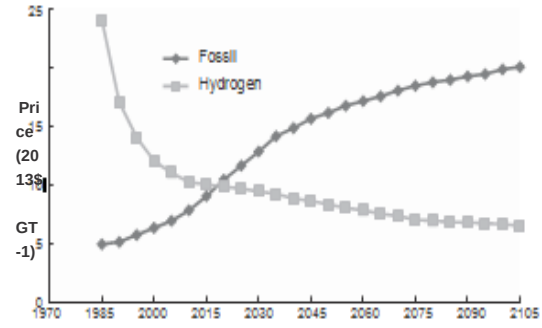

Fig. 7(b) Graphical Representation of Hydrogen and Fossil Fuel Price Estimation vs Time.

V. Waste toEnergy (WTE) Challenges

Totally separation of various kinds of garbage isextremelytough. WTE technologies weredesigned to handle waste such as biomass, solid waste, etc. Exact determination

 DOI : 10.35291/2454-9150.2021.0448

of composition of waste or garbage source is almost impossible. If WTE technologies have to become successful then (i)They must become more resourceful or (ii) they have to be improved in material handling and sorting system.The enumerable WTE challenges are conversion efficiency, waste gas cleaning, regulatory obstacles and high cost. In this regard the gas generated from waste by various methods like thermal gasification and pyrolysis should be cleaned and free from pollutants. Low efficiency working was found in many wastes to energy model plants, mainly for those spending energy severeprocedures (ex- plasma). Toxic resources are associated with both trace organics (i.e. furans and dioxins) and also trace metals (i.e. mercury, lead and cadmium).Trace metals and trace organics can cause many environmental problems, if these are allow to present into soil and air and further allowance to shift to groundwater, or make a way to reach food chain. The key feature of environmental regulation is the control of air pollution by controlling trace metals and trace organics (toxins) governingpower generation from municipal waste. The monitoringweather for WTE technology is tremendouslycompound. In the regard of airsuperiorityapprehensions, the environmental regulations prohibit the methods of incineration. Though small producers are able to participate with the recognized power benefits in many areas due to the changes in power industries, the electric grid is still protected by more regulation. Waste energy producers face obstacles due to these regulations. The installation of WTE technologies isvery expensive. As emerging technologies are not broadly established in the market due to this high installation cost is a big challenge, despiteof the financial benefits they promise (Fig.7)exemplifiespossible hydrogen and fossil fuelcosts till the year 2015-16. The picturepropossesthat the costs of hydrogen areexpected to decrease while the prices of fossil fuel are expected to increase.

VI. Technology Used for Conversion of Waste into Energy

The household wastes which are generally produced every day can be converted into valuable items, like heat, electricity and fuel energy. The municipal wastes which are created on a large scale can be turned intogaseous stage for generation of energy. The electricity can be generated on combustion of solid waste present in the landfills. Various types of wastemust have a waste to energy facility that incinerates it and converts chemical energy into thermal energy.

Fig. 8 Coal Like Material

The methods mentioned below are used to convert waste into energy. The general technique ofturning waste to energy is thermal (incineration) conversation, biochemical conversation and physio-chemical conversation. These methods are simply explained below:

VI.I Thermochemical Conversion

Generally, there are three main techniques of thermochemical turning of waste into green and usable energy. These are (i) Burning in surplusof oxygen,(ii) Gasification in compact oxygen and (iii) Pyrolysis, when there is insufficiency in presence of oxygen. Burning directly in the presence of excess oxygen is the preferred process for the production heat and energy from municipal garbage. Small-scale technology to large grid-connected amenities is the range of collective heat and power (CHP). CHP provides ominously moreproductivities than systems that only produce electricity. The techniques are listed below accordingly:

VI.I.i PULVERIZATION

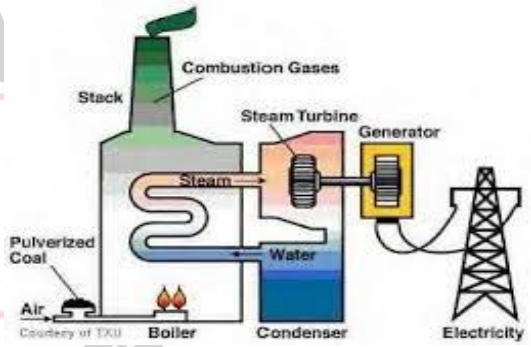

Fig.9 Conversion through Pulverization

In the method of pulverization of plastic garbage, colored powder and general properties are obtained. The pulverized particles have smooth and elongated formaccredited to great shear situations.These particles also exhibitphysical and mechanical properties better or similar than the
Properties subsequent fromconservativetreating of PCW(Post Consumer Waste)

VI.I.ii.TORREFACTION

The method by which biomass is transformed into a coal like structure (which has better fuel properties than general biomass) is called the thermal process of torrefaction. Brittle, making grinder easier with less energy investment are some properties of torrefied biomass. Due to biological degradation and water uptake in fewer amounts, the storage of biomass can be simplified when compared to fresh biomass.

VI.I.iii PLASMA GASIFICATION

The process of converting landfill garbage to extract recyclable commodities and convert carbon material into

 DOI : 10.35291/2454-9150.2021.0448

material is called the method of plasma gasification.Whilst caring for the environment, integral component in a system to achieve zero-waste and produce renewable fuels canbe formed by plasma gasification. The treatment of hazardousgarbage (such as incinerator ash and chemical weapons) and converting harmful garbage into harmless slag can be done by the process of plasma arc.

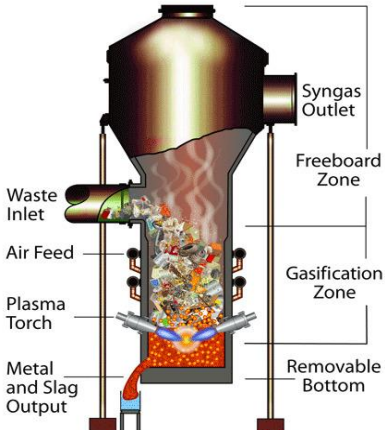

Fig.10 Plasma Gasification

VI.I.iv GASIFICATION

The creation of energy from domestic waste is a developing process of thermo-chemical gasification. In the gasification method, carbondioxide, carbon-monoxide and a small amount of hydrogen at high temperature and in presence of oxygen is obtained by converting carbonaceous substances. The process of thermos-chemical gasification leads to the generationof synthesis gas which is a good source of substitute fuel fuel. The production of electricity and heat is possible through synthesis gas.

VI. I.v PYROLYSIS

The creation of energy from garbage produced by the side of manufacturing product is essential in factories and industries done by the process. This is mostly like hydrous-pyrolysis including the use of hydrogen dioxide and water. The process of pyrolysis uses organic and natural (agricultural)garbage from industries.

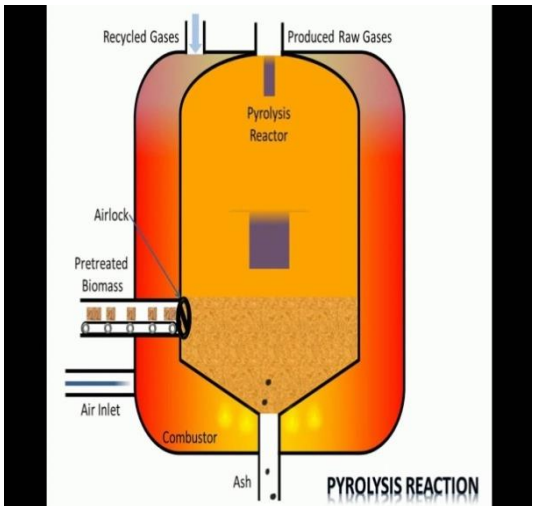

Fig. 11 Pyrolysis

VI.I.vi PLASMA ARC GASIFICATION

A plasma burn down is casted-off to ionize gas from the produced compressing gas,in the plasma arc gasification

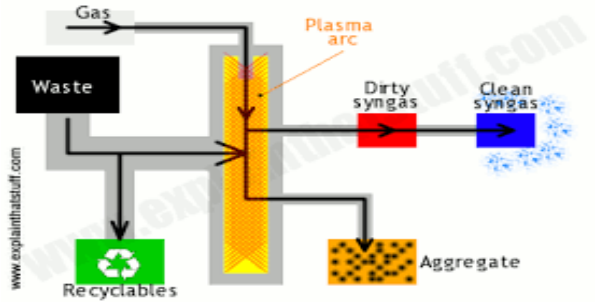

Fig.12 Plasma Arc Gasification

process. The green electricity is produced using synthesis gas.

The creation of better and sustainable is possible through the methods of turning municipal waste into recyclable green energy the developing world where the resources are used in so large scale and the waste produced is in so large quantity. Technologies made for better mankind is an essential tool for saving our ecosystem and to solve the energy crisis of the world. Though the gauge of energy is generated by following method is quite less till now, it can create a significant change in the use and generation of energy in the upcoming future [15].

VI.II Biochemical Conversion

In this technique biogas has been obtained as a form of sustainable energy and clean energy by the process of anaerobic digestion. A specific gas engine convertor is used to convert this to power and heat energy. The production of green electricity and heat using garbage is possible through utilizing biogas which is a result of degraded municipal garbage from homes.

VI.II.i ANAEROBICDIGESTION

The transformation of organic waste into bio chemical fertilizersis the method of anaerobic digestion in absence of air.For the management of wet waste and organic waste along with municipal waste, anaerobic breakdown method is most suitable technology.

Fig. 13 Anaerobic Digestion

Anaerobic respiration refers to the process through which biodegradable substances are broken down by the actions of microorganisms. Management of waste or the generation of green energy on small scale is possible through anaerobic respiration which can be used for industrial or household purposes.

 DOI : 10.35291/2454-9150.2021.0448

VI.II.ii DEPOLYMERIZATION

The process of transforming a polymer into a mixture of monomers is called the process of depolymerization.Thermal decomposition in water is used by the process of depolymerization.In the method of depolymerization, the biological compounds of garbage are heated to generate heat energy at a very high temperaturedepolymerization is the process to convert waste into necessary fossil fuel when needed.

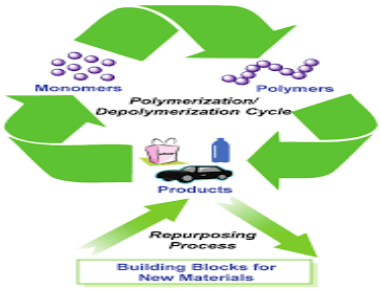

Fig.14Depolymerization Cycle

VI.IIIPhysico-chemical Conversion

The third method of change of garbage to energy is physico-chemical technology which involves numerous processes; which are involved to increasechemical and physical properties of solid garbage generated across the world. The thermal segment of the garbage is generally transformed into highly energized fuels that may cause the generation of steam energy. First of all the solid garbage is dried in the Sun to reduce its moisture level. The mechanical process are used before the garbage compressed for the separation of grit, sand and other large matter and then transformed into fuel energy. This fuel energy has numerous well defined differentbenefitsabove traditional wood and coal burning,since it is a cleaner source of energy and able from combustibles and has minor

VI.III.i OMNI PROCESSOR

The Omni process is the technique which generally converts human waste into drinking water and electricity which is the clean form of energy usable by humans without any adverse effect to mankind. Human wastes are treated by the technologies called Omni processors. All the pathogens present in sludge can be removed using Omni processor. The nutrients present in soil might be recycled as a practice of reuse of excreta inagriculturewhich is the better alternative [16, 17]. The prime objective is to proper management of bacteria which breakdown the extentof disease from fecal slurry and to create sustainable and green energy.

Fig.15 Dumping of Human Waste in River Bodies

VI.III.ii SEDRON TECHNOLOGY

Sedron technology was presented in 2014 a prototype combustion using thermal energy. This process is similar to the Omni processes which treat the sewage sludge thatis used to produce drinking water & electrical energy.

10801 litres of drinkable H_2O every day and 101kw electricity can be produced using the sedron technology; this is the capacity of one sedron technology plant. Also, 86,001 litres of drinkable H_2O every day and 251 kW net output electricity can be produced from the waste of 1, 00,000 people with a large model of Sedron Technology [16]. Sedron system is made to provide a "self-sustaining bioenergy" method.

Following are the processes involved in the treatment:

(i) heating the sludge ,(ii) the water vapour is collected through condensation, (iii)the dry sludge left behind is used to boil in step(i), the cycle keeps on going which helps minimize the cost of the plant,(iv)the generation ofelectrical energy is produced using steam in the step(ii). Final reverse osmosis purification stage to generate safe drinking water and to generate ancillary pumps, fans andmotors is done using electrical energy.A pilot project of Sedron technology in

form of Omniprocessor was fitted inDakar, Senegal, in 2015 and can treat the feceswaste of 50,001-100,001 individuals [18]

Fig.16 Sedron Technology Plant

Fig.16 Sedron Technology Plant

VII. Conclusion

This paper gives a brief knowledge on densegarbage which can be reused for a cause of bioenergy in Indiacomprising municipal solid waste and integrated solid waste. Municipal solid waste's configuration and physicochemical features are the key understanding for administration of dense waste and valorization. Turning waste into energy is not a new idea but it requires special devotion. Several energy transformation techniques including biochemical, thermochemical and mechanical extractions can create valuable products like heat, energy and transportation fuel.Green energy generation is the substitute of petroleum products which will overcome the enslavement on overseas countries and restrict the pollution and greenhouse gas emissions.In India,different types of waste might be think as alternate source of energy.

 DOI : 10.35291/2454-9150.2021.0448

The application of landfill dumpingmethods must be focused for the valorization of biogas.

References

[1] A. Vitorino de Souza Melaré, S. Montenegro González, K. Faceli, and V. Casadei, "Technologies and decision support systems to aid solid-waste management: a systematic review," *Waste Management*, vol. 59, pp. 567-584, 1// 2017.

[2] J. Portugal-Pereira and L. Lee, "Economic and environmental benefits of waste-to-energy technologies for debris recovery in disaster-hit North east Japan," *Journal of Cleaner Production*, vol. 112, Part 5, pp. 4419-4429, 1/20/ 2016.

[3] P. T. T. Trang, H. Q. Dong, D. Q. Toan, N. T. X. Hanh, and N. T. Thu, "The Effects of Socio-economic Factors on Household Solid Waste Generation and Composition: A Case Study in Thu Dau Mot, Vietnam," *Energy Procedia*, vol. 107, pp. 253-258, 2// 2017.

[4] D. Hoornweg and P. Bhada-Tata, "What a waste: a global review of solid waste management," 2012..

[5] L. A. Guerrero, G. Maas, and W. Hogland, "Solid waste management challenges for cities in developing countries," *Waste Management*, vol. 33, pp. 220-232, January 2013.

[6]B. Antizar-Ladislao and J. L. Turrion-Gomez, "Decentralized Energy from Waste Systems," *Energies*, vol. 3, p. 194, 2010.

[7] Matsakas L, Rova U, Christakopoulos P. Strategies for enhanced biogas generationthrough anaerobic digestion of forest material - An overview. BioResources 2016;11:5482–99.

[8] Matsakas L, Christakopoulos P. Ethanol production from enzymatically treateddried foodwaste using enzymes produced on-site. Sustainability 2015; 7: 1446–58. http://dx.doi.org/10.3390/su7021446.

[9] Pham TPT, Kaushik R, Parshetti GK, Mahmood R, Balasubramanian R. Food waste- to-energy conversion technologies: Current status and future directions. Waste Manag 2015; 38:399–408. http://dx.doi.org/10.1016/j.wasman.2014.12.004.

[10] Melikoglu M, Lin C, Webb C. Analysing global food waste problem: Pinpointing the facts and estimating the energy content. Open Eng. 2013;3:157–64. doi: http://dx.doi.org/10.2478/s13531-012-0058-5.

[11] Uçkun Kiran E, Trzcinski AP, Ng WJ, Liu Y. Bioconversion of food waste to energy: A review. Fuel 2014; 134:389–99. http://dx.doi.org/10.1016/j.fuel.2014.05.074.

[12] UçkunKiran E, Trzcinski AP, Ng WJ, Liu Y. Enzyme production from food wastes using a biorefinery concept. Waste Biomass Valorization 2014; 5:903–17. http://dx.doi.org/10.1007/s12649-014-9311-x.

[13] Svensson Myrin E, Persson PE, Jansson S. The influence of food waste on dioxin formation during incineration of refuse-derived fuels. Fuel 2014; 132:165–9. http://dx.doi.org/10.1016/j.fuel.2014.04.083.

[14] Edo M, Budarin V, Aracil I, Persson PE, Jansson S. The combined effect of plastics and food waste accelerates the thermal decomposition of refuse-derived fuels and fuel blends. Fuel 2016; 180:424–32. http://dx.doi.org/10.1016/j.fuel.2016.04.062.

[15] David Nicoll Types of Waste That Can Be Turned Into Energy. *September 26, 2017*

[16] "BBC news article "Bill Gates drinks water distilled from human feces"". Retrieved 11 January 2015.

[17] "From poop to portable, This Ingenious Machine Turns Feces Into Drinking Water". gatesnotes, The Blog of Bill Gates. 5 January 2015. Retrieved 13 January 2015.

[18] "The firms turning poo into profit". BBC News Business Section. 16 November 2016. Retrieved 17 November 2016

 DOI : 10.35291/2454-9150.2021.0448