ChemSearch Journal 4(1): 57 – 61, June, 2013
Publication of Chemical Society of Nigeria, Kano Chapter

Received: 08/01/2013 Accepted: 19/04/2013

Utilization of Wastes as an Alternative Energy Source for Sustainable Development: A REVIEW

[1]M.U. Muhammad, [1]L.Abubakar, [2]A. Musa and [1]A.S. Kamba
[1]Department of Chemistry, ShehuShagari College of Education, Sokoto
[2]Department of Chemistry, Umaru Musa Yar'adua University, Katsina
E-mail: aminuy2008@yahoo.com;

ABSTRACT
Generally, the greater the economic prosperity and the higher percentage of urban population, the greater the amount of solid waste produced. Reduction in the volume and mass of solid waste is a crucial issue especially in the light of limited availability of final disposal sites in many parts of the world. To meet the rising demand for energy and to address environmental concerns, a conversion from conventional energy systems to renewable resources is essential. For the sustainability of human civilization, an environmentally techno – economically feasible waste treatment method is very important to treat waste. Several technologies are available for converting solid waste to energy source, ranging from very simple systems of disposing of waste to more complex technologies capable of dealing with large amounts of industrial waste. There are three main pathways for conversion of waste material to energy: thermochemical, biochemical and physicochemical conversion. Therefore, this paper examines how waste can be utilized to produce energy for sustainable development with adequate use of science and technology. It is recommended that, awareness campaign should be carried out to enlighten the general populace on the benefit of utilizing waste to energy source.

Keywords: *Waste, sustainable development, utilisation, energy source.*

INTRODUCTION

The enormous increase in the quantum and diversity of waste materials generated by human activity and their potentially harmful effects on the general environment and public health, have led to an increasing awareness, world-wide, about an urgent need to adopt scientific methods for safe disposal of wastes. While there is an obvious need to minimize the generation of wastes and to reuse and recycle them, the technologies for recovery of energy from wastes can play a vital role in mitigating the problems. Besides recovery of substantial energy, these technologies can lead to a substantial reduction in the overall waste quantities requiring final disposal, which can be better managed for safe disposal in a controlled manner while meeting the pollution control standards (Salman, 2012).

Energy crisis in the developing Nations of the World is currently at an alarming rate and the need to proffer solutions is not only expedient but must be of high priority. It is based on this that the Nigerian Federal Ministry of Science and Technology and some agencies such as National Biotechnology Development Agency (NABDA), Energy Commission of Nigeria (ECN) and National Research Institute for Chemical Technology (NARICT) recognizes the importance of energy production and utilization for the benefit of Mankind.

The increased world population and the quest to improve living conditions have resulted in an increased demand for energy. This has placed an increased demand in the exploration and depletion of energy resources (mainly fossil fuel). Fossil fuels have a huge negative impact on the environment. Combustion results in the emission of green house gases which are responsible for global warming. This consequently results in extreme change in climatic conditions, uncontrollable rise in pollution of air, water, and soil which poses a serious threat to human survival on earth. The forecast that Africa would suffer the greater impact of climatic change coupled with the inadequate energy supply, has placed Africa and other developing countries on the quest for alternative/sustainable energy (Solomon, 2009).

Network of advisory councils from several European countries was established to promote the exchange of information and ideas on environmental and sustainable-development policies. As a result, this prompted the need to protect, safe guide, manage and conserve the natural resources for sustainable development which could balance the needs, economy and environment of the society (Ivbijaro *et al.,* 2006).

This paper examines a review on how waste can be utilized to produce energy for sustainable development.

WASTE

Wastes are materials that are not prime products (that is products produced for the market) for which the initial user has no further use in terms of his own purposes of production, transformation or consumption, and of which he wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals, recycled or reused at the place of generation are excluded (UNEP, 2005).

Ibrahim (2002) viewed waste as an unwanted materials or substances generated in the process of production and consumption of goods. In developed countries, over 500 to 800 tonnes of refuse are generated per day, while in less developed countries refuse generated are more easier to compost or generate biogas, but difficult to compress or incinerate (Burrow, 1995).

Waste can be classified in so many different ways, thus: according to source e.g. municipal, industrial; according to solute e.g. solid, liquid, gas; according to property e.g. hazardous, toxic, non-toxic etc. But there are many types defined by modern systems of waste management, notably:

- Municipal Waste; Household Waste, Commercial Waste and Demolition Waste.
- Hazardous Waste; Industrial Waste, Agricultural Waste, Explosives Waste.
- Bio-medical Waste includes Clinical waste, Radioactive Waste, and Electronic Waste (e-waste) (UNEP, 2005).

WASTE-TO-ENERGY CONVERSION PATHWAYS

Waste generation rates are affected by socio-economic development, degree of industrialization and climate change. Generally, the greater the economic prosperity and the higher percentage of urban population, the greater the amount of solid waste produced. Reduction in the volume and mass of solid waste is a crucial issue especially in the light of limited availability of final disposal sites in many parts of the world (TIBRD, 1999).

A number of wastes – to – energy conversion pathways are now well known of realizing the potential of waste as an energy source, ranging from very simple systems for disposing of dry waste to more complex technologies capable of dealing with large amounts of industrial waste. There are three main pathways for conversion of organic waste material to energy; thermochemical, biochemical and physicochemical.

Thermochemical conversion, characterized by higher temperature and conversion rates, is best suited for lower moisture feedstock and is generally less selective for products (Salman, 2012). This process is useful for wastes containing high percentage of organic non – biodegradable matter and low moisture content. The main technological options include Combustion, Pyrolysis, Gasification and Incineration (Sharmina *et al.*, 2012).

Combustion or burning is the sequence of exothermic chemical reactions between a fuel and an oxidant accompanied by the production of heat and conversion of chemical species. Incineration is a waste treatment process that involves the combustion of organic substances contained in waste materials. This process maintains a controlled combustion of waste with the recovery of heat to produce steam which in turn produces power through steam turbines. Pyrolysis and Gasification represent refined thermal treatment methods as alternatives to incineration and are characterized by the transformation of the waste into product gas as energy carrier for later combustion e.g a boiler or a gas engine (Sirvio and Rintala, 2002; Salman, 2008). In thermochemical conversion all of the organic matter, biodegradable as well as non – biodegradable, contributes to the energy output. The amount of energy recovered in waste is very sensitive to the efficiency of the process (Feo *et al.,* 2003).

The bio-chemical conversion processes, which include anaerobic digestion and fermentation, are preferred for wastes having high percentage of organic biodegradable (putrescible) matter and high moisture content. Anaerobic digestion can be used to recover both nutrients and energy contained in organic wastes such as animal manure. The process generates gases with a high content of methane (55–70 %) as well as biofertilizer. Alcohol fermentation is the transformation of organic fraction of waste to ethanol by a series of biochemical reactions using specialized microorganisms. Cellulosic ethanol can be produced from grasses, wood chips and agricultural residues by biochemical route using heat, pressure, chemicals and enzymes to unlock the sugars in biomas wastes (Salman, 2012).

The physico-chemical technology involves various processes to improve physical and chemical properties of solid waste. The combustible fraction of the waste is converted into high-energy fuel pellets which may be used in steam generation. Fuel pellets have several distinct advantages over coal and wood because it is cleaner, free from incombustibles, has lower ash and moisture contents, is of uniform size, cost-effective, and eco-friendly (Salman, 2012). The factors which determine potential of recovery of energy from wastes are quantity and quality (physicochemical characteristics) of the waste. Some of the important physicochemical parameters requiring consideration include: size of constituents, density, moisture content, volatile solid/organic matter, fixed carbon, total inerts and calorific value (Diaz *et al.*, 1982).

Strahler and Strahler (2007); Saleh (2008); Gartner Lee Limited (2005) and Uchegbu (2008), reported that waste materials are being recycled to gives the following; Refuse derived fuel (fuel derived by shredding and steaming municipal waste), Biogas (gas derived from biomass using anaerobic digestion), Syngas (gas generated from gasification process by partial combustion of municipal waste), Ethanol (fuel generated from fermentation of agricultural wastes), Energy from incineration (energy derived from complete combustion of municipal waste in an oxygen rich environment), and Energy from used oil (energy generated from refining the oil drained from automobiles or other machines)

FEEDSTOCK FOR WASTE-TO-ENERGY CONVERSION PLANTS

Agricultural Residues

Large quantities of crop residues are produced annually worldwide, and are vastly underutilised. The most common agricultural residue is the rice husk, which makes up 25% of rice by mass. Other residues include sugar cane fibre (known as bagasse), coconut husks and shells, groundnut shells, cereal straw etc. Current farming practice is usually to plough these residues back into the soil, or they are burnt, left to decompose, or grazed by cattle. A number of agricultural and biomass studies, however, have concluded that it may be appropriate to remove and utilise a portion of crop residue for energy production, providing large volumes of low cost material. These residues could be processed into liquid fuels or combusted/gasified to produce electricity and heat (Sirviö and Rintala, 2002).

Animal Waste

There are a wide range of animal wastes that can be used as sources of biomass energy. The most common sources are animal and poultry manures. In the past this waste was recovered and sold as a fertilizer or simply spread onto agricultural land, but the introduction of tighter environmental controls on odour and water pollution means that some form of waste management is now required, which provides further incentives for waste-to-energy conversion. The most attractive method of converting these waste materials to useful form is anaerobic digestion which gives biogas that can be used as a fuel for internal combustion engines, to generate electricity from small gas turbines, burnt directly for cooking, or for space and water heating. Food processing and abattoir wastes are also a potential anaerobic digestion feedstock (Dhussa and Varshney, 2000).

Sugar Industry Wastes

The sugar cane industry produces large volumes of bagasse each year. Bagasse is potentially a major source of biomass energy as it can be used as boiler feedstock to generate steam for process heat and electricity production. Most sugar cane mills utilise bagasse to produce electricity for their own needs but some sugar mills are able to export substantial amount of electricity to the grid (Rao, 1999).

Forestry Residues

Forestry residues are generated by operations such as thinning of plantations, clearing for logging roads, extracting stem-wood for pulp and timber, and natural attrition. Wood processing also generates significant volumes of residues usually in the form of sawdust, off-cuts, bark and woodchip rejects. This waste material is often not utilised and often left to rot on site. However it can be collected and used in a biomass gasifier to produce hot gases for generating steam (Mapuskar, 1997).

Industrial Wastes

The food industry produces a large number of residues and by-products that can be used as biomass energy sources. These waste materials are generated from all sectors of the food industry with everything from meat production to confectionery producing waste that can be utilised as an energy source. Solid wastes include peelings and scraps from fruit and vegetables, food that does not meet quality control standards, pulp and fibre from sugar and starch extraction, filter sludges and coffee grounds. These wastes are usually disposed of in landfill dumps (Gunasegarane, 2002).

Liquid wastes are generated by washing meat, fruit and vegetables, blanching fruit and vegetables, pre-cooking meats, poultry and fish, cleaning and processing operations as well as wine making. These waste waters contain sugars, starches and other dissolved and solid organic matter. The potential exists for these industrial wastes to be anaerobically digested to produce biogas, or fermented to produce ethanol, and several commercial examples of waste-to-energy conversion already exist (Rao, 1999).

Municipal Solid Waste (MSW)

Millions of tonnes of household waste are collected each year with the vast majority disposed of in landfill dumps. The biomass resource in MSW comprises the putrescibles, paper and plastic and averages 80% of the total MSW collected. Municipal solid waste can be converted into energy by direct combustion, or by natural anaerobic digestion in the landfill. At the landfill sites the gas produced by the natural decomposition of MSW (approximately 50% methane and 50% carbon dioxide) is collected from the stored material and scrubbed and cleaned before feeding into internal combustion engines or gas turbines to generate heat and power. The organic fraction of MSW can be anaerobically stabilized in a high-rate digester to obtain biogas for electricity or steam generation (Dhussa and Varshney, 2000).

Sewage

Sewage is a source of biomass energy that is very similar to the other animal wastes. Energy can be extracted from sewage using anaerobic digestion to produce biogas. The sewage sludge that remains can be incinerated or undergo pyrolysis to produce more biogas (Dhussa and Varshney, 2000).

Black Liquor

Pulp and Paper Industry is considered to be one of the highly polluting industries and consumes large amount of energy and water in various unit operations. The wastewater discharged by this industry is highly heterogeneous as it contains compounds from wood or other raw materials, processed chemicals as well as compound formed during processing. Black liquor can be judiciously utilized for production of biogas using UASB technology (Rao, 1999).

CONCLUSION

The waste-to-energy plants offer two important benefits of environmentally safe waste management and disposal, as well as the generation of clean electric power. Waste-to-energy facilities produce clean, renewable energy through thermochemical, biochemical and physicochemical methods. The growing use of waste-to-energy as a method to dispose off solid and liquid wastes and generate power has greatly reduced environmental impacts of municipal solid waste management, including emissions of greenhouse gases. Waste-to-energy conversion reduces greenhouse gas emissions in two ways. Electricity is generated which reduces the dependence on electrical production from power plants based on fossil fuels. The greenhouse gas emissions are significantly reduced by preventing methane emissions from landfills. Moreover, waste-to-energy plants are highly efficient in harnessing the untapped sources of energy from a variety of wastes. Therefore, this paper shown with enough and adequate use of science and technology, waste can be utilized as a source of energy and awareness campaign should be carried out to enlightened people on the benefit of utilizing waste as source of energy for sustainable development

REFERENCES

Burrow, C.J. (1995). Developing the Environment: Problems and Management, Longman, Harlow, p275.

Dhussa A.K., and Varshney, A.K. (2000). Energy Recovery from Municipal Solid Waste - Potential and Possibilities, Bio Energy News, p7.

Diaz, L.F., Sarage, G.M. and Golueke, C.G. (1982): Resource Recovery from Municipal Solid Wastes, Vol. 2 Final Processing, CRC Press, Florida, p1.

Feo, G.D., Belgiorno, V., Rocca, C.D. and Napoli, R.M.A. (2003): Energy from Gasification of Solid Wastes, Waste Management, (23): 1 – 15.

Gartner Lee Limited. (2005). New and Emerging Residual Waste Management Technologies, Paper for Regional District of Nanaimo (RDN) and Cowichan Valley Regional District (CURD), Canada.

Gunasegarane, G.S. (2002). Energy from Dairy Waste, Bio Energy News, p26.

Ibrahim, A.M. (2002). Introduction to Environmental Problems and Management, Waadallah Environmental Consults (WADEC). Kano.

Ivbijaro, F.A.M., Akintola, F. and Okechukwu, R.U. (2006).Sustainable Environmental Management in Nigeria; Mattin Production Ibadan, Nigeria, p251 – 267.

Mapuskar, S.V. (1997). Biogas from Vegetable Market Waste at APMC Pune, Bio Energy News, p16.

Rao, R.P. (1999). Energy from Agro Waste - A Case Study, Bio Energy News, Aligarh, India, p 21.

Saleh, Y. (2008). The Management of Waste As a Resources Paper Presented at the Nigerian Institute of Management Monthly Meeting, 15 – 17 April, Kaduna.

Salman, Z. (2012): Waste to Energy Conversion. A Global Perspective, Alternative energy eMagazine. India, p7 – 17.

Salman, Z. (2008): Conversion Efficiency of Municipal Solid Waste – to – Energy. Access at 15th November, 2011 http://www.Energycentral.net/blog/08/10/conversion.efficiency – msw – energy.

Sharmina, B., Rasul, M.G. and Delwar, A. (2012): An Investigation on Thermochemical Conversions of Solid Wastes for Energy Recovery. World Academy of Science, Engineering and Technology, 6(2). 624 – 630.

Solomon B.O. (2009): Sustainable Utilization of Energy and Biodiversity. Resources for Wealth Creation and Development NAM S&T (Centre for Science and Technology of the Non – Alligned and other Developing Countries) centre's publication p348.

Sirviö, A., and Rintala, J. A. (2002). Renewable Energy Production in Farm Scale: Biogas from Energy Crops, Bio Energy News, p16.

Strahler, A. and Strahler, A. (2007). Physical Geography: Science and Systems of the Human Environment. John Wiley and Son, 2nd Edition, India, Pp. 154 – 156.

The International Bank for Reconstruction and Development (1999): What a Waste: Solid Waste Management in Asia, Urban Development Sector Unit, East and Pasific Region, Washington, DC., U.S.A.

Uchegbu, S.N. (2008). Environmental Management and Protection, Second Edition, Precision Printers and Publishers, Enugu, Nigeria, p201.

United Nations Environment Programme (UNEP) (2005), Solid Waste Management. Chapter III: Waste Quantities and Characteristics, Pp 31-38.