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Energy from Marine Litter

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Abstract

Marine litter is a well known global issue. Litter is a mixture of trash dumped out of domestic, industrial, and hospital activities. Those wastes create more impacts on geological, biological, and economical entities. In toto, litter causes aesthetic blight of beaches. So, it is of importance to protect beaches from man-made and natural activities that wither away its pristine environment. Such wastes are to be managed under reduce, recycle and reuse domains. Among the management strategies of wastes, production of energy attains prime level as it serves both 3R's and power generation. However, energy from waste, particularly from marine litter is a little bit complex; because debris mingles with sand deposits and it requires special handling technologies. Sifting, sorting mobilizing and putting it to the energy producers are important stages in obtaining energy from waste. Incineration reduces the volume of the original waste by 95-96% depending upon composition and degree of recover material such as metals from ash for recycling. Power can be produced from waste through combus facility. This study focuses on energy from waste material, especially from beaches and as a viable alternative energy source. While organic litter can be used as agricultural fertilizers, some amount of energy can be obtained by incineration of inorganic litters. Velankanni beach litter was studied as a case for renewable energy.

Keywords: Marine litter, marine debris, renewable energy, energy from waste, Coastal Tamil Nadu, Religious places.

Introduction

Considerable amount of waste accumulate along coastal zones, especially in beaches dotted with religious places. Consequently, visitors would avoid such beaches not only to avoid polluted atmosphere and sand but also dislike ugly scenario. It mounts to diminishing revenue to local populace and the administration. Visitors, unmindful, leave a large amount of trash along beaches.

This forms a significant part in marine litter. Therefore, public and private enterprises with certain concern on the tidiness of the beaches involve in coastal cleanup. While beach sand is being cleaned by government agencies, it also takes initiatives to regulate littering through several legislations. Is there any use to this growing mass of litter? If anyone could make use of such marine debris, it would not only help him but also fetch income to the beach administrators and a way out for the disposal of such huge (growing) pile of solid waste composed of degradable and non-degradable waste material. In this line of thought, the authors assessed the possibility of generating energy from such marine litter.

Generally, it has been a practice to incinerate the waste and the heat is used to turn the turbines of electricity generator. It also forms a part of environmental conservation strategy, i.e., reduce, reuse and recycle. It also minimizes the land requirement for dumping and landfilling, transportation expenses, and pollution; and even reduces aesthetic blight due to ugliness of the litter-mount scenario.

The Honolulu Strategy, a framework for dealing with the marine debris, was born out of the support and assistance of scientists, practitioners, managers, and the private sector from around the world in conjunction with the United Nations Environment Programme (UNEP) and National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program after the Fifth International Marine Debris Conference held in March 2011 at Hawaii. Classification of organic and inorganic was followed by survey sheets as suggested in the UNEP/ IOC guidelines on survey and monitoring of marine litter, the Marine Conservation Society (MCS, 2004), and Beach Watch survey protocols. The Environmental Agency/ National Aquatic Litter Group (EA/NALG, 2000) survey protocols, the Ocean–Watch method, WWF marine debris survey protocols and the ocean conservancy's national marine debris monitoring program protocols. Rajput et al., (2009) studied on Municipal solid waste generation showed different trend and a positive correlation with economic development in term of kg/capita/day solid waste generation at world scale.

Energy conversion attempts:

Waste-to-energy or energy-from-waste is energy recovery in the form of electricity and/or heat from the incineration of waste. These processes produce electricity and/or heat directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels (Wikipedia).

The latent energy present in its organic fraction can be recovered for gainful utilization through adoption of suitable waste processing and treatment technologies. Energy can be recovered from the organic fraction of waste (biodegradable as well as non - biodegradable) through two methods as follows:

Thermo-chemical and bio-chemical conversions enable decomposition of litter producing heat energy or fuel or methane gas or alcohol. The Thermo-chemical conversion processes are useful for wastes containing high percentage of organic non-biodegradable matter and low moisture content. High moisture content causes biodegradable waste fractions to decompose more rapidly than in dry conditions. It also makes the waste rather unsuitable for thermo-chemical conversion (incineration, pyrolysis/ gasification) for energy recovery as heat must first be supplied to remove moisture.

The following table shows percentage of energy that can be obtained from composite litter (CPHEEO, 2000.).

Table 1: Percentage of energy obtained from composite litter.

Waste Treatment method	**Basic principle**	**Waste parameters**	**Desirable Energy**
Thermo-chemical conversion -Incineration -Pyrolysis -Gasification	Decomposition of organic matter by heat	Moisture content/ Volatile Matter Fixed carbon Total inert Calorific value	< 45% >40% <15% >1200K-Cal/ Kg
Bio-chemical conversion	Decomposition of organic matter by microbial action	Moisture content	>50% > 40

Source : CPHEEO, 2000.

U.K., U.S.A., Austria, Canada, Sweden are a few countries which successfully derive energy from waste. Ministry of Urban Development, Government of India (2000) released a manual on solid waste management to promote waste to energy programmes in India. Gobar gas plant is run with the organic litter to produce methane gas and the residue is sent as agricultural fertilizer.

Methodology:

This study, between 2009-2012, focuses on energy from waste material collecting along Velankanni beach. Marine litter were sorted to degradable and non-degradable types and accordingly energy extractive methods differ. A surveyor's measuring tape and global positioning system (GPS) were used for beginning and

endpoints of the 100 m^2 study site. In the event that it was not permissible or possible to mark a study site, a natural or man-made landmark such as the large rock, or building was accurately noted. Prevailing winds and surface residual currents are onshore. Study areas were also chosen on the basis of their close proximity to populated towns, tourism and or fishing grounds and therefore close to the points of marine litter discharge.

Velankanni beach

As a case-study, energy from marine litters accruing in Velankanni Beach was taken up. Velankanni is a well-known small town in Nagapattinam district of Tamil Nadu located on the shores of the Bay of Bengal and 12 km south of Nagapattinam on the Coromandel Coast, at 10.40°N 79.49°E. Velankanni receives a highest tourist inflow among Indian coastal zones. Velankanni is a well-known pilgrim center (Roman Catholic shrine dedicated to Our Lady of Good Health) of South India. Throughout the season, this beach receives tourists and pilgrims of all ages and communities. The Living Population of the Velankanni is 12,500. During weekends, the number of visitors rises to 20,000 and nearly 40,000. In addition, around 50,000 during the summer vacations. Festival season is last week of August first week of September during this period 1,00,000 people visit the town. Therefore, there is no doubt of surge of litters voluminously.

The local villagers take care of marine food needs of the tourists by fishing. There are cottage industries for craft and candle making. So, debris originate both from recreational, fishing and marine activities and other sources. Field studies show the littering rate is high throughout the year. This warrants removal or recycling of litter throughout the year (TNPCB, 1999).

Quantitative estimations of litter along Velankanni beach were made by laying out 10 grids measuring 10 m x 10 m on the beach. All the litter items within each of the 100 square meter area were collected. Their weight and the number were recorded on the data sheets especially prepared to accommodate litter composition and/ or specific identification (UNEP, 2009). In fact, the sampled litter was the remains left in the coast after manual cleaning by the local municipality.

Recycling of marine litter

Proper cleaning and removing were primary aspects for recycling Marine Litter. This indirectly reduces the distribution over the sandy beach. Proper recycling increases the aesthetic value of the beach which in converse increases the tourist attraction to the study area. A rough assessment of the potential of recovery of energy from beach litter through different treatment methods can be made from a knowledge of its calorific value and organic fractions.

Formula 1

In thermo-chemical conversion all of the organic matter, biodegradable as well as non-biodegradable, contributes to the energy output as follows:

Total waste quantity : W tonnes

Net Calorific Value : NCV k-cal/kg.

Energy recovery potential (kWh) = NCV x W x 1000/860 = 1.16 x NCV x W

Power generation potential (kW) = 1.16 x NCV x W/ 24 = 0.048 x NCV x W

Conversion Efficiency = 25%

Net power generation potential (kW) = 0.012 x NCV x W

If NCV = 1200 k-cal/kg., then

Net power generation potential (kW) = 14.4 x W

Formula 2

In bio-chemical conversion, only the biodegradable fraction of the organic matter can contribute to the energy output

Total waste quantity: W (tonnes)

Total Organic / Volatile Solids: VS = 50 %, say

Organic bio-degradable fraction : approx. 66% of VS = 0.33 x W

Typical digestion efficiency = 60 %

Typical bio-gas yield: B (m3)= 0.80 m3 / kg. of VS destroyed

= 0.80 x 0.60 x 0.33 x W x1000 = 158.4 x W

Calorific Value of bio-gas = 5000 kcal/m3 (typical)

Energy recovery potential (kWh) = B x 5000 / 860 = 921 x W

Power generation potential (kW) = 921 x W/ 24 = 38.4 x W

Typical Conversion Efficiency = 30%

Net power generation potential (kW) = 11.5 x W

Anaerobic Digestion (AD)

In this process, also referred to as bio-methanation, the organic fraction of wastes is segregated and fed to a closed container (biogas digester) where, under anaerobic conditions, the organic wastes undergo bio-degradation producing methane-rich biogas and effluent/ sludge. The biogas production ranges from 50-150m^3/ tonnes of wastes, depending upon the composition of waste. The biogas can be utilised either for cooking / heating applications, or through dual fuel or gas engines or gas/steam turbines for generating motive power or electricity.

The sludge from anaerobic digestion, after stabilisation, can be used as a soil conditioner, or even sold as manure depending upon its composition, which is determined mainly by the composition of the input waste.

Landfill Gas Recovery

The waste deposited in a landfill gets subjected, over a period of time, to anaerobic conditions and its organic fraction gets slowly volatilized and decomposed according to the process similar to that taking place in an Anaerobic Digestion system as detailed in the previous section. This leads to production of landfill gas containing about 45-55% methane, which can be recovered through a network of gas collection pipes and utilised as a source of energy. Typically, production of landfill gas starts within a few months after disposal of the wastes and generally lasts for about ten years or even more depending upon mainly the composition of wastes and availability / distribution of moisture. The yearly gas production rates observed in full size sanitary Landfills in other countries range from 5-40 litre/kilogram. The MSW generated in major Indian cities is rich in organic matter and has the potential to generate about 15-25 l/kg of gas per year over its operative period.

Incineration

It is the process of direct burning of wastes in the presence of excess air (oxygen) at temperatures of about 8000C and above, liberating heat energy, inert gases and ash. Net energy yield depends upon the density and composition of the waste; relative percentage of moisture and inert materials, which add to the heat loss; ignition temperature; size and shape of the constituents; design of the combustion system (fixed bed/ fluidised bed), etc. In practice, about 65 to 80 % of the energy content of the organic matter can be recovered as heat energy, which can be utilised either for direct thermal applications, or for producing power via steam turbine generators (with typical conversion efficiency of about 30%). The combustion temperatures of conventional incinerators fuelled only by wastes are about 760^{o} C in the furnace and in excess of 870^{o}C in the secondary combustion chamber. These temperatures are needed to avoid odour from incomplete combustion but are insufficient to burn or even melt glass. To avoid the deficiencies of conventional incinerators, some modern incinerators utilise higher temperatures of up to 1650^{o}C using supplementary fuel. These reduce waste volume by 97% and convert metal and glass to ash. Wastes burned solely for volume reduction may not need any auxiliary fuel except for start-up. When the objective is steam production, supplementary fuel may have to be used with the pulverized refuse, because of the variable energy content of the waste or in the event that the quantity of waste available is insufficient.

While Incineration is extensively used as an important method of waste disposal, it is associated with some polluting discharges which are of environmental concern, although in varying degrees of severity. These can fortunately be effectively controlled by installing suitable pollution control devices and by suitable furnace construction and this has been accomplished through identification of any markings present on specific debris items and potential uses of these items.

Results and Discussion

Beach environment withholds litters from multiple sources like domestic, recreational industrial fishing etc. Incineration of composite waste has high calorific value.The analysis of one month data helps to identify that this particular zone is much suitable for power generation from Marine Litter.

Table 2 Descriptive statistics of organic and inorganic fractions of solid waste in tonnes

Statistic	Inorganic	Organic
Mean	1.17	0.50
Standard Error	0.05	0.02
Median	1.12	0.48
Mode	0.98	0.42
Standard Deviation	0.28	0.12
Sample Variance	0.08	0.01
Kurtosis	0.28	0.24
Skewness	1.02	0.99
Range	0.98	0.43
Minimum	0.84	0.35
Maximum	1.82	0.78
Sum	35.18	15.05
Largest(1)	1.82	0.78
Smallest(1)	0.84	0.35
Confidence Level (95.0%)	0.11	0.05

Table 2 provides descriptive statistics of organic and inorganic fractions of solid waste collected from Velankanni for the month of May, 2010

Table 3: Amount of energies that could be obtained by recycling solid waste		
Type of material	**CV (MJ / kg)**	**CV (kCal / kg)**
Medical waste	19 - 24	4540 - 5735
Industrial & hazardous waste	22 - 40	5257 - 9558
Domestic waste (without recycling)	7 - 16	1673 - 3823
Domestic waste (afther recycling)	10 - 14	2389 - 3345
PVC	41	9797
Dry wood	14,4	3441
Paper	13,5	3226
Braun carbon	7 - 12	1673 - 2867
Petrol (benzine)	45 - 47	10573 - 11231
Coal	15 - 27	3584 - 6452
Diesel	46	10992
Ethanol	30	7168

Table 3 shows the calorific values obtained by incineration of composite waste. by calculating the data in the above formula for power generation we could get as follows. In an average 1.05 Tonnes of Inorganic and 0.51 tonnes of organic remains are collected from the beach. Ruby (2013) Studied on the aesthetics of beach Litter and reported the aesthetic value of beach is being polluted by distribution of coastal litter This is capable to generate 15.12 KW of electricity from inorganic waste and 5.57 KW of electricity by organic waste treatment. In total 20.69 KW, of power is much enough for the fulfillment of Eight square km of velankanni and adjacent zone that does not possess any industrial power consumption. From the study it is recommended that Velankanni beach is a potential zone to generate power energy.

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